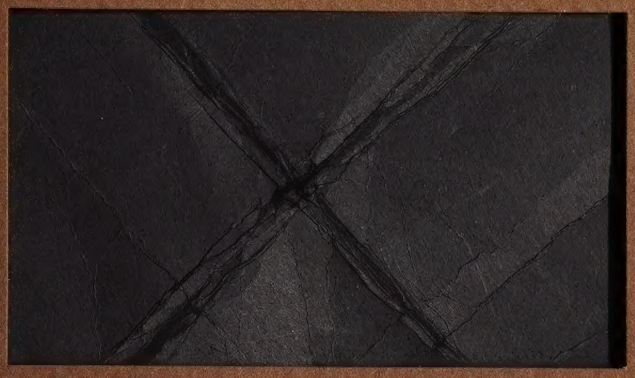
DATA-CONTROL SYSTEMS, INC.



INSTRUCTION MANUAL

FM SUBCARRIER DEMODULATOR
Model GFD-16

This manual covers the following Models:

Model GFD-16	Serial Numbers beginning 290.
Model GFD-16A	Serial Numbers beginning 291.
Model GFD-16B	Serial Numbers beginning 291.

DCS DATA·CONTROL SYSTEMS, INC. Commerce Drive, Danbury, Connecticut 06810 ■ 203 743-9241

This material is the property of Data-Control Systems, Inc. and is furnished for the installation and operation of DCS products only. Reproduction of these contents or use for any commercial purpose without prior permission is forbidden. All rights in this material are reserved.

DOCUMENT NO: 710129
710129-A
710129-B
710129-C

PUBLICATION DATE: 1/29/71(Preliminary)
8/23/71
9/13/72
6/21/73

TABLE OF CONTENTS

Paragraph		Page
	SECTION I—GENERAL AND LEADING PARTICULARS	
1-1	General	1-1
1-4	Purpose and Scope	1-1
1-9	Electrical Characteristics	1-1
1-11	Physical Characteristics	1-1
	SECTION II—INSTALLATION	
2-1	Introduction	2-1
2-3	System Planning	2-1
2-6	Physical Installation	2-1
2-7	Unpacking and Handling	2-1
2-8	System Connectors	2-1
2-9	Demodulator Installation	2-1
2-10	Cooling	2-3
2-11	System Adjustments and Checkout	2-3
	SECTION III—OPERATION	
3-1	General	3-1
3-3	Controls and Indicators	3-1
3-5	Operating Procedure	3-1
3-6	Starting Procedure	3-1
3-7	Monitoring Procedure	3-1
3-8	Turn-Off Procedure	3-1
	SECTION IV—THEORY OF OPERATION	
4-1	General	4-1
4-3	A Radio Telemetry System	4-1
4-6	Block Diagram Discussion	4-1
4-7	Subcarrier Selection	4-1
4-9	Limiting	4-1
4-10	Demodulation	4-1
4-13	Tape Speed Compensation	4-3
4-14	Low Pass Filter	4-3
4-15	Data Voltage Output Circuit	4-4
	SECTION V—MAINTENANCE	
5-1	General	5-1
5-3	Test Equipment Required	5-1
5-5	Preventive Maintenance	5-1
5-8	Performance Checks	5-1
5-10	Performance Test Setup	5-2
5-11	Zero Check	5-2
5-12	Gain Control Range Check	5-2
5-13	Polarity Check	5-2
5-14	Overall Frequency Response Check	5-2
5-15	Output Current Limit Check	5-2
5-16	Tape Speed Compensation Check	5-3
5-17	Troubleshooting	5-3
5-20	Alignment	5-3

TABLE OF CONTENTS (cont)

Paragraph — Page

SECTION VI—SCHEMATIC DIAGRAMS

SECTION VII—PARTS LIST

7-1 Introduction 7-1
7-3 Ordering Information 7-1
7-5 How To Use The Parts List 7-1
7-7 Ref Symbol Column 7-1
7-8 Description Column 7-1
7-9 Manufacturer's Part Number Column 7-1
7-10 Manufacturer Column 7-1
7-11 Total Qty Column 7-1

LIST OF ILLUSTRATIONS

Figure — Page

1-1 Model GFD-16 Subcarrier Demodulator iv
2-1 Typical Input and Output Connections 2-2
2-2 Rear View of GMA Module Connectors for One Demodulator 2-3
3-1 GFD-16 Operating Controls and Indicators 3-2
4-1 Model GFD-16 Functional Block Diagram 4-2
4-2 Demodulation by Double Pulse Averaging 4-3
5-1 Output Current Limiting Waveforms 5-2
5-2 Main Board 5-6
5-3 Bandpass Filter 5-7
5-4 Low Pass Filter 5-7
6-1 Schematic Diagram, Model GFD-16 6-3

LIST OF TABLES

Table — Page

1-1 Electrical Specifications 1-1
1-2 Equipment Supplied 1-3
1-3 Physical Specifications 1-4
2-1 Elco Pin Connections 2-1
2-2 GMA Module Signal Connectors 2-3
3-1 Controls and Indicators 3-1
5-1 Test Equipment Required 5-1
5-2 Dc Voltage Measurements 5-4
7-1 Parts List 7-2

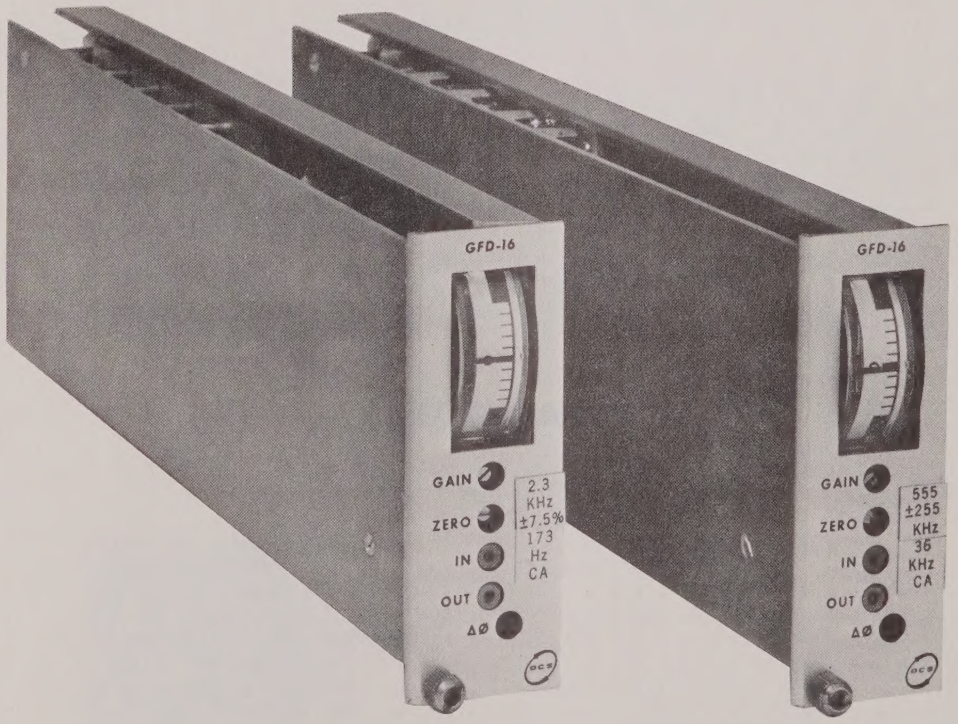


Figure 1-1. Model GFD-16 Subcarrier Demodulator

SECTION I
GENERAL DESCRIPTION AND LEADING PARTICULARS

1-1. GENERAL.

1-2. This publication contains information for understanding, operating, and maintaining the Model GFD-16 FM Subcarrier Demodulator, figure 1-1, designed and manufactured by Data-Control Systems, Inc., Commerce Drive, Danbury, Connecticut, 06810.

1-3. This information is presented in the following sections: Section I, General Description and Leading Particulars; Section II, Installation; Section III, Operation; Section IV, Theory of Operation; Section V, Maintenance and Troubleshooting; Section VI, Drawings; and Section VII, Parts List.

1-4. PURPOSE AND SCOPE.

1-5. The Model GFD-16 is a compact double pulse-averaging fm demodulator designed for use as a data discriminator or tape speed compensation reference signal processor in ground telemetry installations. The unit provides demodulated analog output for application to strip-chart recorders, quick-look displays, and data processing instruments.

1-6. The GFD-16 demodulates fm subcarrier frequencies within the range of 400 Hz to 2 MHz, either single channel or multiplexed, with deviations from ±1% to ±40%, and produces output data with frequencies from dc to 64 kHz. Modulated subcarrier signals are selected from a multiplex by the GFD-16 bandpass filter (which is not used on the GFD-16-01), its modulating signal is then detected through a double pulse-averaging technique and the resulting output signal (data) is filtered by the GFD-16 low-pass filter. The low pass filter can be furnished with an optional $\Delta\emptyset$ adjustment which permits delay matching of channels in time correlated data. The non-adjustable single frequency filters can be furnished with either constant amplitude or linear phase characteristics. Bandpass and accompanying low-pass filters are printed circuit boards that mount on the main assembly board.

1-7. When used as a tape speed compensation reference processing unit, the GFD-16-03 selects the reference tone and detects variations in the tone due to tape speed variations. The detected signal is low-pass filtered and applied to one or more data demodulators as an offset signal to compensate for the FM effect to data subcarriers caused by the tape speed variations.

1-8. A signal polarity reversal switch is incorporated in the GFD-16. The output signal polarity switch reverses the output signal and is useful when processing translated signals.

1-9. ELECTRICAL CHARACTERISTICS.

1-10. The electrical specifications of the GFD-16 are listed in table 1-1. Section II describes typical systems using the GFD-16 Demodulators.

1-11. PHYSICAL CHARACTERISTICS.

1-12. The GFD-16 is installed in a standard 19 inch GMA Module Assembly Power Supply which provides all power, cooling, and interconnection for as many as 14 GFD-16, GFD-16-01, or GFD-16-03 Demodulators in 3-1/2 inches of vertical space. The complete demodulator consists of three printed circuit (pc) boards. The main assembly contains all of the circuitry except the bandpass filter and the low-pass filter. These filters are mounted on two boards that mount on the main assembly. To meet specific requirements, several types of filter boards are available. Their model numbers and reference designation assignments are listed in table 1-2. The physical characteristics of the demodulator are given in table 1-3.

1-13. The main assembly mates with the GMA connector, through which all power and signal connections are established. The front panel contains a zero-center meter that indicates the average subcarrier position in the band, a GAIN control that adjusts the band-edge voltage, the ZERO control, and IN (input) and OUT (output) test jacks. A captive screw on the front panel secures the unit to the GMA. Identification labels attached to the front panel describe the tuning unit center frequency and deviation and the cutoff frequency and characteristic of the low pass filter that is installed. The GAIN and ZERO adjustments are accessible through holes in the front panel.

TABLE 1-1. ELECTRICAL SPECIFICATIONS

Parameter	Characteristics
Subcarrier input frequency:	
GFD-16	0.4 kHz - 2.0 MHz
GFD-16-01	1.3 kHz - 1.5 MHz
GFD-16-03	Standard reference frequencies

TABLE 1-1. ELECTRICAL SPECIFICATIONS (Cont'd)

Parameter	Characteristics
Subcarrier deviation:	
GFD-16	±1% - ±25%
GFD-16-01	±25% - ±40%
GFD-16-03	
Input impedance	At least 100 kilohms, shunted by a capacitance of not more than 75 picofarads.
Input selectivity (attenuation at 3 deviations):	
GFD-16	At least 24 dB
GFD-16-01	(no bandpass filter)
GFD-16-03	At least 24 dB
Dynamic input signal range:	
400 Hz to 300 kHz	2 mV to 2 V rms
300 kHz to 2 MHz	8 mV to 2 V rms
Amplitude modulation rejection	An output peak transient of less than 0.5% of full band-width is produced for a 20 dB change in center frequency subcarrier level anywhere within the dynamic input range utilizing a channel with a modulation index of 5 or greater.
Tape speed compensation for wow and flutter frequencies up to 20 kHz with variations of ±2%:	
At MI = 5 (CBW systems)	At least 30 dB improvement
At MI = 2 (CBW systems)	At least 20 dB improvement
Static speed changes (PBW systems)	At least 30 dB improvement
Capacitive loading capability	Capacitive drive capability remains at 0.01 microfarad for all output frequencies from DC to 64 kHz. (Not to exceed rated output current.)
Output zero temperature coefficient	Less than 100 ppm/°C of center frequency over a range of 0°C to 50°C.
Deviation sensitivity instability	Not greater than ±0.05% in 15 hours after a 15 minute warmup.
Harmonic distortion:	400 Hz - 300 kHz / 300 kHz - 2 MHz
MI = 2	Not greater than 0.75% / Not greater than 1.0%
MI = 5 or greater	Not greater than 0.25% / Not greater than 0.3%
Noise:	
Deviations not over ±16%,	
MI = 5, 400 Hz to 300 kHz	Not greater than 0.03% of full bandwidth rms or 30 mV p-p at 20 V p-p output level.
MI = 5, 300 kHz to 2 MHz	Not greater than 0.065% of full bandwidth rms or 65 mV p-p at 20 V p-p output level.
MI = 2, 400 Hz to 300 kHz	Not greater than 0.05% of full bandwidth rms or 50 mV p-p at 20 V p-p output level.
MI = 2, 300 kHz to 2 MHz	Not greater than 0.1% of full bandwidth rms or 80 mV p-p at 20 V p-p output level.

TABLE 1-1. ELECTRICAL SPECIFICATIONS (Cont'd)

Parameter	Characteristics
Deviations over ±16%,	
MI = 5, 400 Hz to 2 MHz	Not greater than 0.1% of full bandwidth rms p-p at 20 V p-p output level.
Nonlinearity from best straight line:	
400 Hz to 300 kHz, deviations not over ±16%	Not greater than 0.05% of full bandwidth.
0.4 to 300 kHz, deviations up to ±25%	Not greater than 0.1% of full bandwidth.
300 kHz to 2 MHz, deviations up to ±16%	Not greater than 0.1% of full bandwidth.
300 kHz to 2 MHz, deviations up to ±25%	Not greater than 0.3% of full bandwidth.
Harmonic distortion:	
MI = 2, 0.4 to 300 kHz MI = 2, 300 kHz to 2 MHz MI = 5, 0.4 to 300 kHz MI = 5, 300 kHz to 2 MHz	Not greater than 0.75% Not greater than 1.0% Not greater than 0.25% Not greater than 0.3%
Output polarity	Switchable output polarity is standard.
Output impedance (to 64 kHz)	Less than 1 ohm
Output voltage (to 64 kHz)	Continuously variable from ±1 to ±10 volts.
Output current (to 64 kHz)	±50 ma **Note** A short circuit will not damage the unit.
Phase adjustment (optional in types 511 and 521 low pass filters)	Adjust output time delay ±3° at LPF cutoff frequency.

TABLE 1-2. EQUIPMENT SUPPLIED

Unit Designation	Schematic Reference Designations	Characteristic
Basic unit[a]		
GFD-16 ( )	0-100	
Bandpass filter	1100	
Reference tuning unit	Board 1: 1100 Board 2: 1200	
GFD-16-03-001 ( )[b]		For TSC Systems using a delay line. Conforms to basic design standard
GFD-16-03-002 through -089 ( )		Non-standard relationship between reference frequency and delay. Last 2 digits of code define delay.

[a] After model designation, specify center frequency and deviation. For example: GFD-16-01 (165 kHz ±15%)

[b] Specify reference frequency

TABLE 1-2. EQUIPMENT SUPPLIED (Cont'd)

Unit Designation	Schematic Reference Designations	Characteristic
GFD-16-03-101 through -189 ( )		For TSC Systems not using a delay line. System Deviation defined by last 2 digits of code (see chart below).

Code	System Dev.	Code	System Dev.	Code	System Devi
11	±62.5 Hz	26	±32 kHz	38	±160 kHz
12	±125 Hz	27	±64 kHz	41	±12.5 kHz
13	±250 Hz	28	±128 kHz	42	±25 kHz
14	±400 Hz	31	±1.25 kHz	43	±50 kHz
15	±500 Hz	32	±2.5 kHz	44	±100 kHz
21	±1 kHz	33	±5 kHz	45	±200 kHz
22	±2 kHz	34	±10 kHz	46	±400 kHz
23	±4 kHz	35	±20 kHz	51	±6 kHz
24	±8 kHz	36	±40 kHz	52	±7 kHz
25	±16 kHz	37	±80 kHz		

Low pass filter[c]	2100	
Used with GFD-16 and GFD-16-01:		
GFD-16/L-51		5-pole constant amplitude (6 Hz to 64 kHz)
GFD-16/L-52		5-pole linear phase (6 Hz to 64 kHz)
GFD-16/L-511[d]		Same as GFD-16/L-51
GFD-16/L-521[d]		Same as GFD-16/L-52

[c]After model designation, specify cutoff frequency. For example GFD-16-02/L-51 (64 kHz).
[d]With ΔØ adjustment.

TABLE 1-3. PHYSICAL SPECIFICATIONS

Parameter	Characteristic	
Dimensions:		
GFD-16, GFD-16-01, -03	3.29 in. H x 1.145 in. W x 10.5 in. D	
Weight:	Uncrated	Shipping
GFD-16, GFD-16-01, -03	1.5 lbs	1.6 lbs
GFD-16/L	0.5 lb.	0.55 lb.
Mounting	Fourteen Model GFD-16, GFD-16-01, or GFD-16-03 Demodulators mount into a Model GMA Module Assembly/Power Supply which occupies 3-1/2 by 19 inches in an EIA type rack. Units are secured in place by a captive screw.	
Temperature range:		
Operating,	0°C to +50°C.	
Storage	-20°C to +70°C.	

1-14. MODELS GFD-16A and GFD-16B.

1-15. The GFD-16A is a directly interchangeable replacement for the GFD-16 and has identical performance characteristics.

1-16. The GFD-16B is identical to the GFD-16 GFD-16A with the addition of "wow and flutter" components necessary for tape speed compensation of PBW channels. All specifications apply, including dynamic compensation equivalent to that of CBW units.

1-17. The bandpass filters are not interchangeable between the GFD-16 and the GFD-16A. They are interchangeable between the GFD-16A and GFD-16B.

1-18. The low pass filters are interchangeable between the GFD-16, GFD-16A and GFD-16B.

1-19. The GFD-16A and GFD-16B, however, have different layouts for the Main Demodulator printed circuit board and the bandpass filter board. Therefore, separate schematics and board layouts (including photographs) have been included in this manual; one of each set applying to the GFD-16 and the other applying to the GFD-16A and GFD-16B.

1-20. Due to differences in the method of calling out the parts list between the GFD-16 and GFD-16A/GFD-16B, separate parts lists are included in Section VII.

1-21. Due to changes in model nomenclature, Table 1-4 should be used in place of Table 1-2 for the GFD-16A and GFD-16B.

Table 1-4. EQUIPMENT SUPPLIED (GFD-16A & GFD-16B).

BASIC UNIT (Deviations of ±1% to ±25%)*

For constant bandwidth (CBW) systems with single deviation, specify: GFD-16A - ① ②

For proportional bandwidth (PBW) systems or mixed deviation constant bandwidth (CBW) systems, specify GFD-16B - ① ②

For units without bandpass filters (Deviations of ±1% to ±40%), specify: GFD-16A-01 - ① ②

LOW PASS FILTER

For low pass filters for use with the above units, specify: GFD-16/L - ③ ④

REFERENCE UNIT FOR TAPE SPEED COMPENSATION

For PBW or mixed deviation CBW systems; delay line required in system, specify GFD-16A-03- ⑤ ⑦

For single deviation CBW systems with reference frequency above highest data channel; no delay line required in system, specify: GFD-16A-03 - ⑥ ⑦

① Center frequency in kHz.

② Deviation in ±kHz or ±%.

③ Filter Type
- -51 5-pole, constant amplitude (CA).
- -52 5-pole, linear phase (LP).
- -56 5-pole, CA, phase equalized.
- -511 5-pole, CA, with phase adjust.
- -521 5-pole, LP, with phase adjust.
- -71 7-pole, CA.
- -72 7-pole, LP.

④ -3 dB cutoff frequency in kHz.

⑤ Reference Unit Type
- -001 Standard system design. Reference frequency at least 3 data deviations above highest channel. Upper band-edge of highest data channel equal to or less than 0.8 times reference frequency.
- -002 to -098 Non-standard system design. Assigned by factory.
- -099 Special design. Requires modification letter assigned by factory.

⑥ Reference Type Unit
- -101 to -198 System deviation defined by last 2 digits of code. See Chart below.
- -199 Special design. Requires modification letter assigned by factory.

⑦ Reference frequency in kHz. Standard frequencies are:

25 kHz	120 kHz	400 kHz
50 kHz	200 kHz	480 kHz
100 kHz	240 kHz	800 kHz

System Deviation Chart (Use with Note 6)

Code	Deviation	Code	Deviation	Code	Deviation	Code	Deviation	Code	Deviation
11	± 62.5 Hz	21	± 1 kHz	31	± 1.25 kHz	41	± 12.5 kHz	51	± 6 kHz
12	±125 Hz	22	± 2 kHz	32	± 2.5 kHz	42	± 25 kHz	52	± 7 kHz
13	±250 Hz	23	± 4 kHz	33	± 5 kHz	43	± 50 kHz	53	± 3 kHz
14	±400 Hz	24	± 8 kHz	34	± 10 kHz	44	±100 kHz		
15	±500 Hz	25	± 16 kHz	35	± 20 kHz	45	±200 kHz		
		26	± 32 kHz	36	± 40 kHz	46	±400 kHz		
		27	± 64 kHz	37	± 80 kHz				
		28	±128 kHz	38	±160 kHz				

* GFD-16A and GFD-16B also available with deviations from ±25% to ±38% on special order. Consult factory for specifications.

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. Installation consists of establishing the external connections required for the desired system (paragraph 2-3), physical installation of the Demodulator(s) (paragraph 2-9), and system adjustments and checkout (paragraph 2-11).

2-3. SYSTEM PLANNING.

2-4. The demodulators may be used singly, in groups up to fourteen (one GMA Module Assembly/Power Supply required), or in groups of more than 14 (2 or more GMAs required). The typical external connections required for fourteen demodulators (when using the Model GMA5-10162) are shown in figure 2-1. The pins to which these connections are made are at the rear of the GMA Housing. Table 2-1 identifies the demodulator connector pin functions; table 2-2 identifies the functions of the GMA signal connectors. Figure 2-1 also identifies some of the external connectors of the GMA. All wow and flutter inputs are connected to J212. This connector is Amphenol Part No. 126-219 and mates with Amphenol Part No. 126-222. Pin A is associated with the first (on the left) demodulator; pin H with the last; pin J is grounded. All other input and output connectors are BNC type UG-657/U, for UG-260/U or UG-88/U cable connectors. When using any other type of GMA consult the appropriate wiring chart (contained in the GMA manual).

2-5. When using tape speed compensation, connect the output of the reference frequency demodulator (pin 19) to the wow and flutter input of all data demodulators (pin 6 of each connector in the same GMA and all pins A through H and K of J212 on all other GMA Modules). Do not ground the wow and flutter input of the reference frequency demodulator as this pin is used for reference frequency output in special cases; the TSC input to reference demodulators is always grounded internally.

2-6. PHYSICAL INSTALLATION.

2-7. UNPACKING AND HANDLING. The unit is sealed in a moisture proof polyethelene blister pack assembly and insulated from shock during shipment with polyurethane foam packing material. Remove the corrugated carton and packing material and perform a general visual inspection. Retain carton and covering until inspection is completed. If the visual inspection discloses physical damage immediately notify the carrier.

2-8. SYSTEM CONNECTORS. Refer to paragraphs 2-4 and 2-5 for the connections to be established. All power and signal interconnections to the GFD-16 are made in the rear of the module through Elco Varicon connectors. The pins, 1 through 20, are numbered from top to bottom as shown in figure 2-2. Pin connections and their functions are listed in table 2-1.

2-9. DEMODULATOR INSTALLATION. The demodulator is designed to be mounted in a DCS type GMA Module Assembly/Power Supply which contains the proper wiring for interconnection. To install the GFD-16 proceed as follows:

a. Before inserting the Demodulator into the GMA Module Assembly/Power Supply, determine the required position of the output polarity switch. Set this slide switch (located inside the chassis) to the rear to obtain positive outputs for positive deviations and to the front for reversed outputs.

b. Note the module designations on the bottom edge of the GMA Module Assembly/Power Supply. Insert the Demodulator into one of the module spaces and apply pressure until connectors engage.

c. Tighten the captive screw until unit is completely installed.

d. If not all GFD-16 spaces are occupied, install blank panels GBP-1 or GBP-2 to maintain cooling efficiency.

TABLE 2-1. ELCO PIN CONNECTIONS

Pin No.	Description
1	Subcarrier input*
2	Subcarrier Input Ground*
3	+35 VDC
4	+12 VDC
5	Ground
6	TSC input
7	-12 VDC
8	-35 VDC
9	+18 VDC
10	-18 VDC
11-18	Not used
19	Output*
20	Output Ground* (shield)

*Coaxial connections on rear of GMA

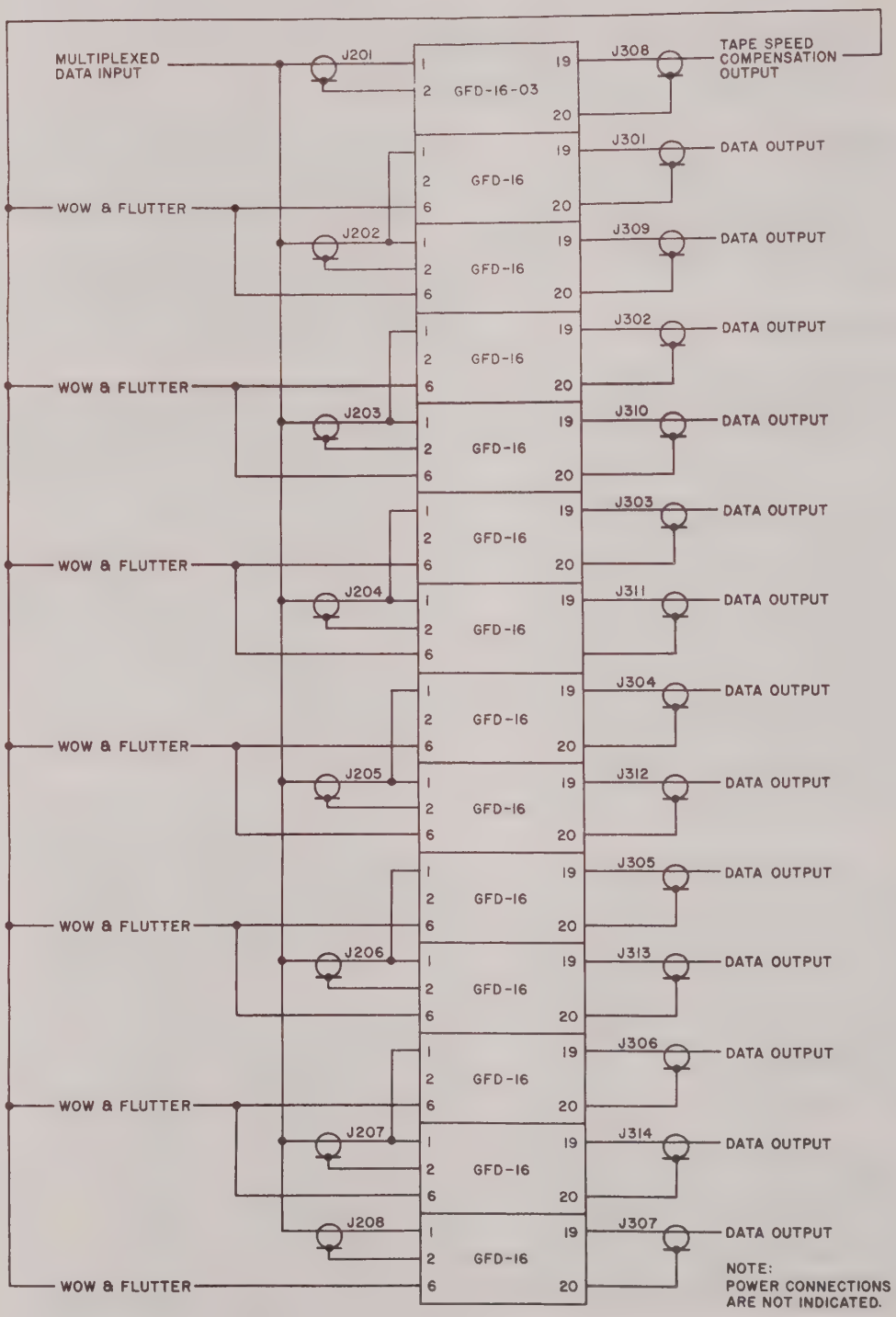


Figure 2-1. Typical Input and Output Connections

TABLE 2-2. GMA MODULE SIGNAL CONNECTORS

Connector	Function
J201-J208	Subcarrier inputs for GFD's 1-14
J212*	Wow and flutter inputs for GFD's 1-14
J301-J314	Data output from GFD's 1-14

*Pin A to GFD-16 No. 1, B to Nos. 2 and 3, C to Nos. 5 and 6.....H to Nos. 12 and 13, K to No. 14, Pin J to Ground.

Note

For normal demodulator operation:

1. Connect TSC input (pin 6) to ground (pin 5).
2. Connect coaxial multiplex line to subcarrier input (pin 1) and the shield (pin 2) to ground.
3. Connect the output (pin 19) and ground (pin 20) to the coaxial line.

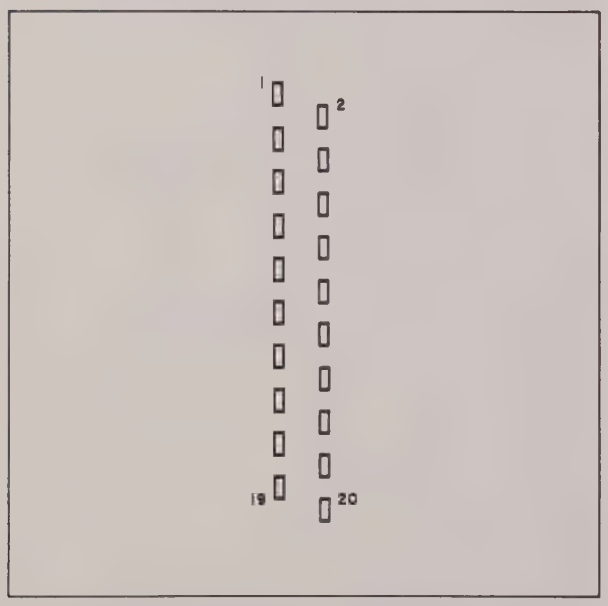



Figure 2-2. Rear View of GMA Module Connectors for One Demodulator

2-10. COOLING. Each GMA Module Assembly is equipped with a muffin fan which pressurizes the assembly to 0.2 inches of water and forces cooling air over the GFD-15. Blank panels must be used over empty module spaces to maintain this pressure.

2-11. SYSTEM ADJUSTMENTS AND CHECKOUT.

2-12. Perform the checkout procedure given in Section V. If, during testing, the equipment does not meet operating specifications, notify Field Service Department, Data-Control Systems, Inc., Commerce Drive, Danbury, Connecticut 06810.

CAUTION

Do not attempt to correct any suspected malfunction by making any internal adjustment.

2-13. Perform the system adjustments as follows:

a. Switch TSC to OFF on Reference Demodulator.

b. Set the GMA power switch ON and allow at least 15 minutes for the units to warm up.

c. During the warm-up period, connect an accurate signal generator and a frequency counter or suitable telemetry subcarrier calibrator to the signal input (figure 2-1).

d. Connect a DC vtvm between the OUT test jack on the front panel.

e. Set the signal source frequency to the Demodulator center frequency and the output to approximately 1 volt.

f. After the warm up period has elapsed, adjust the ZERO screwdriver control for a null on the vtvm.

g. Set the signal source to the higher bandedge frequency. The built-in panel meter should read +100%.

h. Adjust the GAIN control until the vtvm reads the desired bandage voltage (between 1 and 10 vdc).

i. For a reference frequency demodulator, switch TSC switch to ON and zero the reference demodulator after all data demodulators and adjust the GAIN controls on the data demodulators as given above.

j. Reduce a data demodulator's input 1% below its center frequency. This must be done accurately with the aid of the frequency counter.

k. Using a second signal source, set the reference frequency demodulator input signal accurately to 1% below its center frequency. (This and the preceding step simulate a lower tape speed.)

l. While monitoring the output voltage at the data demodulator's OUT test jack with a vtvm, adjust the GAIN control of the reference frequency demodulator until the vtvm reads null.

Note

Final adjustment should be accomplished under actual system conditions.

SECTION III
OPERATION

3-1. GENERAL.

3-2. This section includes the location and function of operating controls and the procedure required to place the GFD-16 Demodulator in operation.

3-3. CONTROLS AND INDICATORS.

3-4. The controls and indicators are illustrated in figure 3-1 and listed in table 3-1.

3-5. OPERATING PROCEDURE.

3-6. STARTING PROCEDURE. It is assumed that the unit has been installed in the GMA Module Assembly, as described in Section II. To turn on the system, proceed as follows:

a. Set the associated GMA power switch to the ON position.

b. Allow a 15 minute warmup period.

c. Zero demodulators and set gain if necessary.

d. With the rack blower assembly switch in the OFF position, check the air flow at the GMA front panel openings to be sure the muffin fan is operating. Turn the rack blower back on and also check to see if it is operating.

3-7. MONITORING PROCEDURE. Periodically during operation, monitor system operation by seeing that the deviation meters follow average data outputs, although they need not be at any specific reading.

3-8. TURN-OFF PROCEDURE. In order to turn off each Demodulator individually, it is necessary to loosen the captive screw and disengage the module from the GMA masterboard by pulling the unit out a few inches. The GMA power switch shuts down all units in the Module Assembly.

TABLE 3-1. CONTROLS AND INDICATORS

Control/Indicator	Designation	Location	Function
ZERO control	R36	Front panel	Adjusts the demodulator to the channel center frequency.
GAIN control	R49	Front panel	Adjusts the analog data output amplitude.
Output polarity switch	S1	Inside on lower front of main chassis. Reached through slot on bottom of GFD-16.	Reverses the polarity of the analog data output voltage.
Output deviation	M1	Front panel	Indicates average position in the band in % of full deviation.
IN test jack	TP1	Front panel	Monitors input signal.
OUTP test jack	TP2	Front panel	Monitors analog data output voltage.
ø adjustment (optional)	R2105	Front panel	Adjusts time delay at low pass filter cutoff frequency.

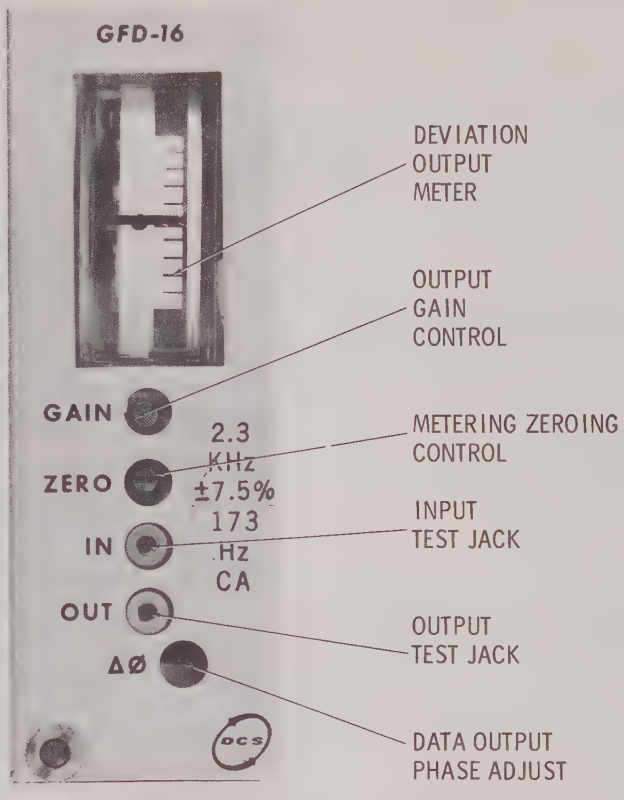


Figure 3-1. GFD-16 Operating Controls and Indicators

SECTION IV
THEORY OF OPERATION

4-1. GENERAL.

4-2. This section describes the theory of operation of the Model GFD-16. The discussion is limited to a detailed block diagram discussion of circuits except where circuit complexity requires detailed descriptions. The schematic referred to in this section is contained in section VI.

4-3. A RADIO TELEMETRY SYSTEM.

4-4. A radio telemetry system conveys data such as temperature and pressure from an inaccessible source such as a drone aircraft or missile to a data recording station. Each parameter measured by the remote transducers is represented by an analog voltage that frequency-modulates a voltage controlled oscillator (VCO). The deviation produced by the VCO then represents the measured data. Each of these signals is called a subcarrier. Up to 21 subcarriers operating at different center frequencies may be used simultaneously in a standard system. The subcarriers are combined (multiplexed) and their sum modulates an fm transmitter that relays the information to the ground station. At the receiving station, an fm receiver reproduces the sum of the subcarriers. This signal, containing all the telemetered data, may be recorded on magnetic tape for future study or it may be fed directly to a group of GFD-16 Demodulators, one for each subcarrier channel. In each Demodulator, a bandpass filter selects a subcarrier channel and rejects all others. Each Demodulator supplies a dc output voltage that is proportional to the deviation of the input frequency from its band center value. Hence the output voltage from each Demodulator is an analog of the data transmitted on its subcarrier channel. The data may be displayed on indicating meters, may be recorded on oscillographs or chart recorders, or may be processed by computers.

4-5. The telemetric data obtained during a mission is frequently recorded on a tape recorder to permit demodulation and analysis at a more convenient time. Tape speed compensation is used in such a system to reduce the errors that result from differences in tape speed between recording and playback. If no compensation for tape speed were used, the output from each Demodulator would contain a dc voltage component that varied with tape speed. To provide compensation, a stable reference frequency, such as 100 kHz, is recorded with the received data. This reference output, when played back, will be frequency-modulated by tape speed variations in the same manner as will all the data subcarriers. For example, a playback speed 1% higher than recording speed produces tape recorder outputs on all subcarriers and on the reference channel that are 1% higher than the recorded frequencies. One Demodulator, a GFD-16-03, demodulates the reference channel, producing dc outputs that vary with tape speed. This "wow and flutter" output is applied to each data Demodulator to offset the output and remove wow and flutter components from the data outputs.

4-6. BLOCK DIAGRAM DISCUSSION. (Figure 4-1.)

4-7. SUBCARRIER SELECTION. The input, containing the desired subcarrier frequency multiplexed with other subcarriers, is applied to the input amplifier emitter follower Q1101 on the bandpass filter board which provides the current needed to drive the bandpass filter.

4-8. The bandpass filter passes the desired subcarrier while rejecting all others. The bandpass filter configuration depends on the % deviation for the channel. The schematic, figure 6-1, shows two configurations. The specific component values depend on the center frequency and deviation and are therefore not given on the schematic. The output of the bandpass filter is coupled through one emitter follower to the first limiter. A second emitter follower provides a voltage at the IN jack that is equal to the subcarrier amplitude applied to the first limiter.

4-9. LIMITING. If the input to the first limiter IC is of sufficient amplitude, the output of the circuit is a 3 volt peak-to-peak clipped sine wave. When lower level inputs are applied, the circuit operates as an amplifier, and the second limiter provides the limiting action. Second limiter IC2 is identical to the first limiter and produces an almost perfect square wave.

4-10. DEMODULATION. The square wave, whose frequency is equal to the input frequency, is applied to the zero crossing detector. This detector produces a narrow positive pulse each time the square wave crosses zero, which occurs at the start of each half-cycle. Thus the pulses occur at precisely twice the input frequency (figure 4-2). Each pulse is applied to and triggers one shot multivibrator IC4, whose pulse width is set to be precisely equal to one-fourth the period of the channel center frequency. Thus at the center frequency, a symmetrical (50% duty cycle) square wave at twice the applied frequency is produced by the one shot multivibrator. The duty cycle of the square wave increases and decreases about 50% as the applied signal frequency varies above and below the center frequency.

4-11. The square wave output of the one shot is applied to switched current source IC5, which draws current from constant current source Q4 when it is switched on. The positive pulses from the one shot turn the switched current source off, allowing the full

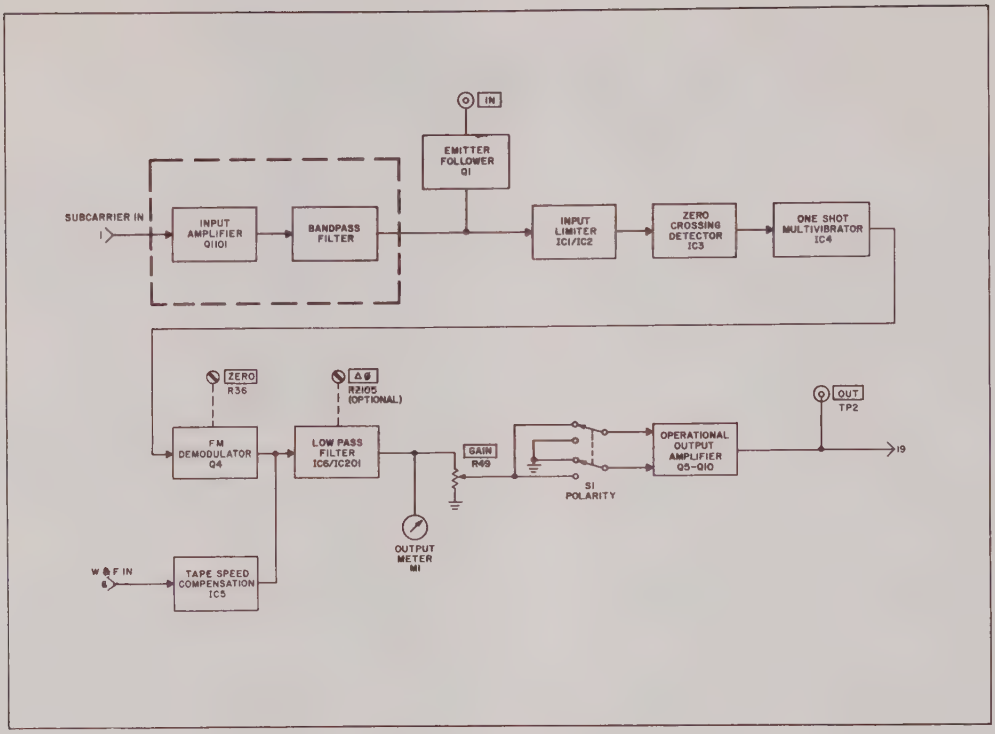


Figure 4-1. Model GFD-16 Functional Block Diagram.

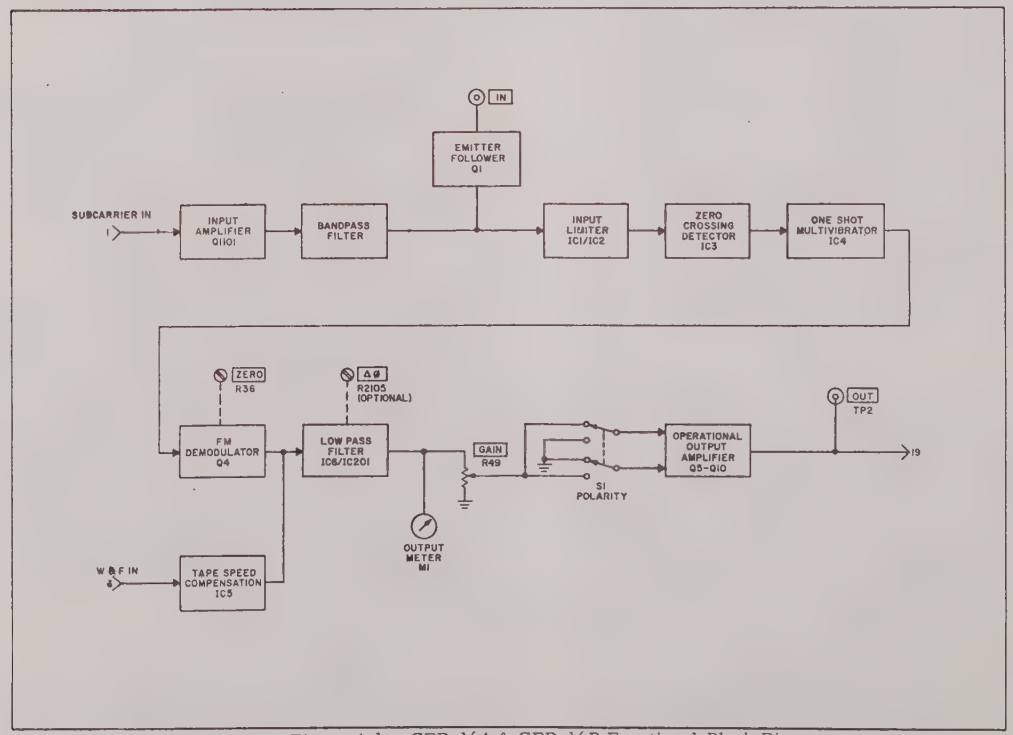


Figure 4-1a. GFD-16A & GFD-16B Functional Block Diagram.

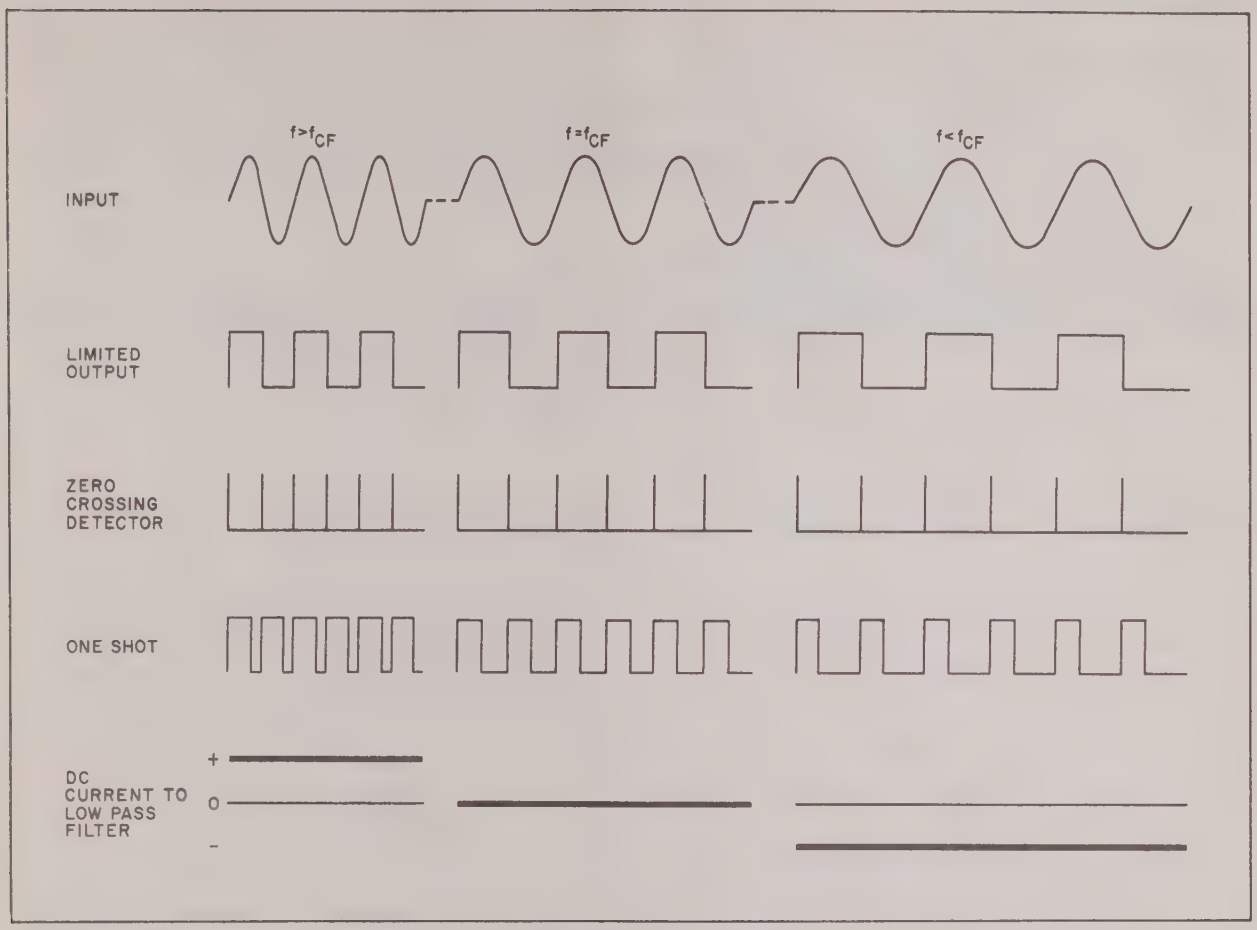


Figure 4-2. Demodulation by Double Pulse Averaging

output i of the constant current source to flow toward the load. When the switched current source is turned on (during the variable time between fixed width pulses), the switched current source draws twice the current supplied by the constant current source. The difference, equal to the current, i, is pulled from the load. Thus the load current is equal in amplitude (assuming no tape speed compensation) during the on and off periods of the switched current source. The ZERO control adjusts this balance condition so that it exists at the center frequency. If the applied signal were equal to the channel center frequency, the on and off periods would be of equal duration and the dc current from the low pass filter would be zero. At higher frequencies the off periods exceed the on periods, and the net current is positive. The amplitude of the dc component is directly proportional to the deviation from center frequency.

4-12. In the constant current source, the diode-connected transistor has its base voltage determined by a zener diode plus the forward drop across the base-emitter junction. This voltage, connected to the base of the emitter follower transistor, controls the voltage across the emitter resistor (plus the identically matched base-emitter junction). In this way, the current in the emitter resistor is fixed.

4-13. TAPE SPEED COMPENSATION. The wow and flutter input is a dc voltage that is positive for increased playback speeds and negative for decreased speeds; the amplitude depends on the percent difference between playback and record speeds. The dc voltage is applied to an adjustable voltage divider, which scales the voltage. These resistors are factory selected so that the wow and flutter input exactly balances out proportional tape-speed-induced deviation from an otherwise unmodulated center frequency signal. This dc input is applied to IC5. Positive input signals, resulting from an increased playback speed, produce more current from K5. This increases the current drawn from the load during the time IC5 is turned on. This negative component of load current balances out (cancels) the positive component produced by the higher data frequency resulting from an increased playback tape speed. Thus the net dc current supplied to the low pass filter is an analog of the telemetered data and is independent of tape speed fluctuations.

4-14. LOW PASS FILTER. A portion of the low pass filter is contained on the main board; the remainder is contained in the low pass filter board. The portion in the tuning unit controls gain so that full scale output is obtained at bandedge for full subcarrier

deviation designed for that tuning unit. The portion in the low pass filter board determines the filter characteristic (CA or LP) and the cutoff frequency. Capacitors C2101 and C2102 in the low pass filter affect the frequency characteristic of the portion in the main board. The output of the low pass filter is applied to the data voltage output circuit. In units with the optional Ø adjustment, fixed capacitor C2103 is replaced by capacitor C2103 shunted by capacitor C2106 in series with Ø adjustment R2105. Adjusting R2105 determines the effect of shunt capacitor C2106 across C2103 and changes the effective capacitance at that point in the filter.

4-15. DATA VOLTAGE OUTPUT CIRCUIT. The low pass filter output is applied to a voltage divider that includes GAIN control R49. This control adjusts the input level to the output amplifier. The output amplifier provides an output of 1 to 10 volts dc at bandedge (2 to 20 volts peak-to-peak for full bandwidth).

4-16. The same voltage that is applied across the GAIN control voltage divider is applied to the deviation meter circuit.

SECTION V
MAINTENANCE

5-1. GENERAL.

5-2. This section provides information necessary for conducting preventive maintenance, performance checks, alignment and troubleshooting of series GFD-16 Demodulators. Troubleshooting procedures are intended to isolate a malfunction to a printed circuit assembly or to one of the replaceable parts listed in Section VI.

CAUTION

Because some alignment procedures require specialized set ups and are critical to the performance of the unit, do not attempt any alignment that is not described in this section. For repair or re-alignment, return the assembly or unit with a full description of requirements (such as center frequency and deviation, low pass filter cutoff frequency and type, CBW or PBW telemetry system) to:

Field Service Department
Data-Control Systems, Inc.
Commerce Drive
Danbury, Connecticut 06810

5-3. TEST EQUIPMENT REQUIRED.

5-4. Table 5-1 lists the name and required characteristics of test equipment needed for maintenance of the Series GFD-16 Demodulator.

5-5. PREVENTIVE MAINTENANCE.

5-6. Because there are no complex mechanical parts, only a visual inspection is needed. A monthly visual inspection should include, but not be limited to, the following checks:

a. Adequate cooling of equipment (provided through the GMA Module), including cleaning of all dust filters.

b. Evidence of overheating such as burned pc cards, resistors, discolored components and wiring, etc.

c. Loose or defective wiring on connectors at rear of unit and on plug-in assemblies.

d. Proper fit of pc cards in the corresponding sockets.

e. Jammed or hard-to-operate panel control.

f. Excessive dust or dirt.

5-7. None of the parts of the GFD-16 require lubrication. Refer to the GMA Instruction Manual for lubrication instructions for the muffin fan.

5-8. PERFORMANCE CHECKS.

5-9. Paragraphs 5-10 through 5-19 contain procedures for measuring the performance of the GFD-16

TABLE 5-1. TEST EQUIPMENT REQUIRED

Equipment	Manufacturer and Type	Required Characteristics
Oscillator, FM	DCS GOV-3 or GOM-5	Produces fm output with required frequency. Because the test accuracy depends on the use of the specified VCO's, do not substitute other VCO's in these tests.
Oscillator, CW	H. P. 651A or equivalent	Generate frequencies to 2 MHz, output to 1V rms.
VTVM, AC	H. P. 400D or equivalent	1 mV to 20V rms, ±3%.
VTVM, DC	Fairchild 7050 or equivalent	.1% +1 digit, 1V-1KV
Frequency Counter	TSI 373R or equivalent	Measure frequency to 2 MHz or above.
Oscilloscope	H. P. 130B or equivalent	Vertical input .2 mV/cm to 500 kHz.
Resistors (2)	Allen Bradley or equivalent	100 ohms, 2 watts

Demodulator. These procedures aid in troubleshooting, double-checking repairs, and ascertaining proper operation of the equipment after extended periods of storage. Because each check presupposes that connections and adjustments of previous checks have been made, these checks must be performed in the sequence specified. Connection points are specified in terms of the GFD-16; equivalent points on the GMA Module may be substituted if this is convenient in the particular set-up.

5-10. PERFORMANCE TEST SETUP.

a. Connect a sine wave oscillator to the input of the demodulator (pin 1). Arrange an ac vtvm to measure the amplitude of the input signal, and the electronic counter to measure its frequency.

b. Connect an ac vtvm and dc vtvm to measure the output voltage (pin 19).

c. Turn the GMA power switch on and allow a minute warmup.

5-11. ZERO CHECK.

a. Set the oscillator to the center frequency of the bandpass filter and the amplitude to 1 vrms. The dc vtvm should read 0. 0 vdc.

b. If the dc vtvm does not read 0. 0 vdc, adjust the 0 control for a reading of 0. 0 vdc.

5-12. GAIN CONTROL RANGE CHECK.

a. Set the oscillator frequency to the high bandedge and, while observing the vtvm, set the GAIN control to full ccw and then to full cw. The dc vtvm should read less than +1. 0 vdc at full ccw and more than +10 vdc at full cw.

b. Reset the gain control for +10 vdc.

5-13. POLARITY CHECK.

a. Take demodulator out of GMA Housing and throw polarity switch, located near the rear of the unit, by means of a screwdriver inserted in cover slot.

b. Replace unit in GMA. Output voltage should now be minus.

c. Reset polarity switch and output level control to give +10. 0 vdc at bandedge.

5-14. OVERALL FREQUENCY RESPONSE CHECK.

a. Disconnect the sine wave oscillator and frequence counter.

b. Connect the fm oscillator unfiltered output to the demodulator input. Set the fm oscillator frequence for 0. 0 vdc at the demodulator output.

c. Connect the sine wave oscillator to the fm oscillator input. Adjust its frequency to 1/10 the cutoff frequency of the low-pass filter being used. Adjust the sine wave amplitude for full bandwidth deviation.

d. While observing the ac output voltage of the demodulator, adjust the frequency of the sine wave oscillator until it is equal to the cutoff frequency of the low-pass filter. The output amplitude at the cutoff frequency should be 3 dB below the low frequency value.

5-15. OUTPUT CURRENT LIMIT CHECK.

a. Connect a 200-ohm load to the demodulator output (pin 19) and observe the waveform. It should be as shown in figure 5-1.

b. Parallel the 100-ohm load with a second 100-ohm resistor. The waveform should change as shown in figure 5-1B. The voltage with current limiting should be approximately 19 volts peak-to-peak.

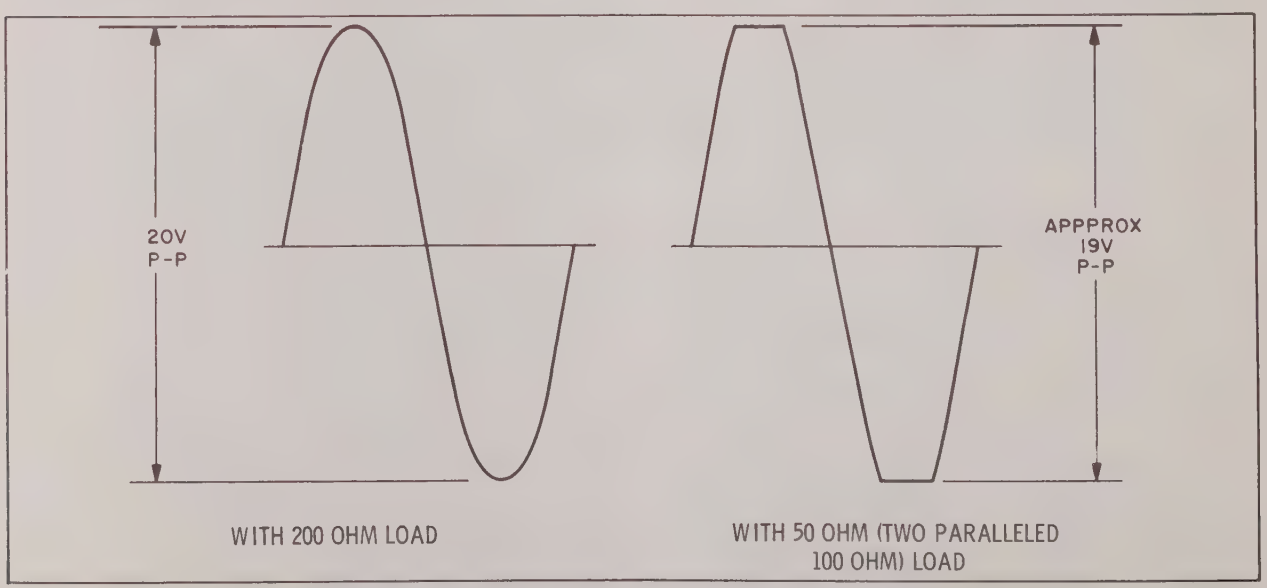


Figure 5-1. Output Current Limiting Waveforms

5-16. TAPE SPEED COMPENSATION CHECK.

a. See that the tape speed compensation input to the demodulator (pin 6, connector A) is not grounded.

b. Remove the sine wave oscillator from the fm oscillator. Set the fm oscillator frequency to band center.

c. Connect the sine wave oscillator to the tape speed compensation input. Set its amplitude to 2.75 volts rms. Set its frequency to 1/10 the low-pass filter cutoff frequency, corresponding to a modulation index of 5. The amplitude of the waveform on the oscilloscope should correspond approximately to ±3% deviation of the channel frequency (e.g. Channel 18, 70 kHz ±15% with a 2.1 kHz low-pass filter would give approximately 4 volts peak-to-peak output at 210 Hz).

5-17. TROUBLESHOOTING.

5-18. The most rapid means of locating a trouble within the demodulator is by signal tracing with test inputs applied. To verify that one of the assemblies contains the defect, substitute another assembly and check to see that the trouble is no longer present. To signal trace, apply the test inputs listed below and check with an oscilloscope for the voltages specified:

Test input	
Tape speed compensation input	5 v p-p, center frequency, undeviated.
1st limiter IC1, pin 9	Ground
2nd limiter IC2, pin 9	3 v p-p*
Zero crossing detector IC3, pin 3	3 v p-p*
One-shot output IC4, pin 1	3 v p-p* (pips at twice input frequency)
Junction of R37, R39, R40	3 v p-p* (square-wave twice fin.)
Tape speed compensation input	Triangular waveform at twice fin; 0 vdc at fin = band center
Low-pass filter (IC2101, pin 12)	1 v p-p sine wave, frequency less than 1/10 deviation.
Tape speed compensation input	0.5 v p-p sine wave
Test input	Ground
Low-pass filter output (pin L16 of board connector)	Modulate input signal with square wave at 1/10xf cutoff at LPF. Modulation amplitude to produce bandedge deviation.
Output amplifier input (terminal 2 of GAIN control)	5 v p-p square wave at modulation frequency; overshoot with standard 5 pole CA filter is 13% ±2%, with standard 5 pole LP filter is 1% ±1%.
	2 v p-p square wave (amplitude obtained when GAIN control is set for 20 v p-p output at pin 19)

*IC voltages are approximate

5-19. After the trouble has been localized using signal tracing, take dc voltage measurements to isolate the defective part in the circuit. Take measurements with a ground tape speed compensation input and an undeviated center frequency input of approximately 1 volt rms.

5-20. ALIGNMENT.

5-21. The adjustments that are not described in the performance checks and below should not be attempted. The test setups required for these other adjustments are too specialized to be practical except at Data-Control Systems, Inc. Adjustment R30 can be adjusted to provide a fine adjustment on tape speed compensation by recording the tape speed reference and channel center frequencies on a tape and then playing the tape into the system. The optimum setting of R30 is that at which the demodulator output remains at 0 vdc in spite of playback speed variations.

a. If IC1204 is replaced, select the value of R1215 so that, with tape speed compensation input grounded, the output at pin 12 of IC1204 is 0 vdc.

b. If IC7 is replaced, the amplifier zero may have to be adjusted. Adjust R51 for normal polarity and R50 for reverse polarity. With the gain pot full

ccw, polarity switch in the normal (+ volts for high bandedge) position, adjust R51 for approximately zero volts output. Reverse output polarity switch and adjust R50 in a similar manner.

Note

Always check the performance of the unit after a repair (paragraphs 5-8 through 5-16).

TABLE 5-2. DC VOLTAGE MEASUREMENTS

Component	Pin	DC Voltage (nominal)*
Q1101	Gate	+3.6
	Source	+2.58
	Drain	+8.99
Q1102	Gate	0.0
	Source	-.59
	Drain	+8.67
Q1	Base	-.59V
	Emitter	-1.22
	Collector	+11.8
Q2	Base	-5.33
	Emitter	-5.97
	Collector	0.0
Q3	Base	-6.19
	Emitter	-6.8
	Collector	0.0
Q4	Emitter 1	0.0
	Emitter 2	+28.94
	Collector 1	+28.35
	Collector 2	+29.97
Q5	Base	-.32
	Emitter	-18.0
	Collector	+17.17
Q6	Base	-.32
	Emitter	-18.0
	Collector	+17.17
Q7	Base	0.0
	Emitter	+.60
	Collector	-18.0
Q8	Base	+.60
	Emitter	0.0
	Collector	+17.94
Q9	Base	0.0
	Emitter	-.62
	Collector	+18.04
Q10	Base	-.62
	Emitter	0.0
	Collector	-17.89
IC1	4	0.0
	5	-5.3
	10	+10.7
IC2	4	0.0
	5	-5.29
	10	+10.7

*Input 220 KHz, square wave, 2.3 VP-P.

TABLE 5-2. DC VOLTAGE MEASUREMENTS (Cont'd)

Component	Pin	DC Voltage (nominal)*
IC3	7	-11.7
	14	-6.0
IC4	1	-10.2
	3, 4	-11.7
	8	0.0
	11	-11.7
	12	0.0
IC5	1	0.0
	4	-10.0
	5	0.0
	6, 9, 11	-15.0
	10, 13	-15.8
IC6	3	-0.2
	4	-0.2
	6	-11.5
	13	+18.04
IC7	3	-0.1
	4	-0.1
	6	-11.5
	13	+18.04
IC2101	3	-.26
	4	-.35
	6	-11.7
	13	+18.0

*Input 220 KHz, square wave, 2.3 VP-P.

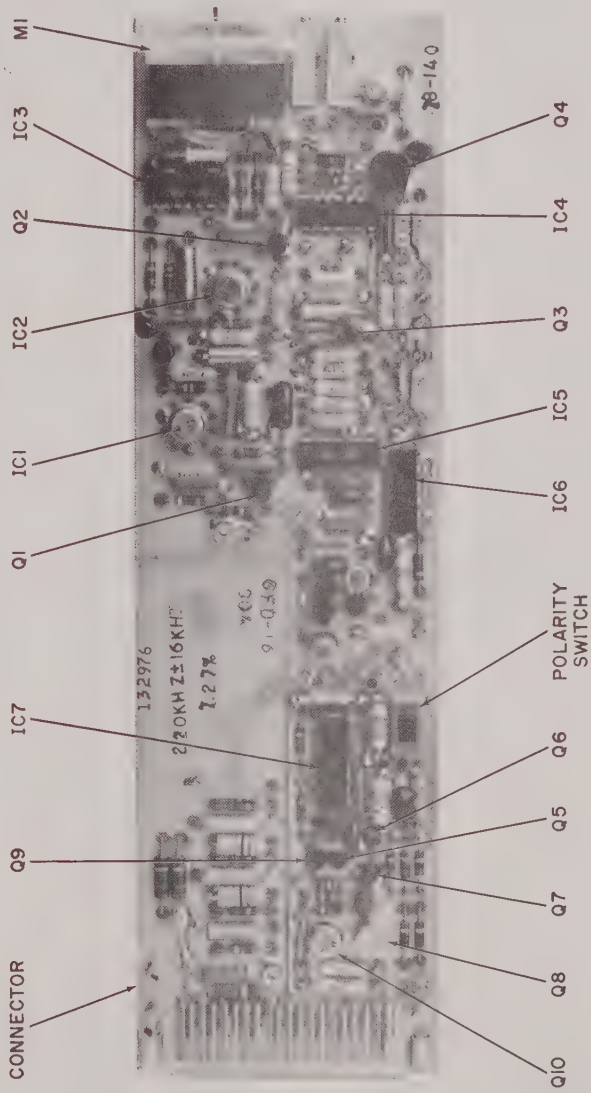


Figure 5-2. Main Board

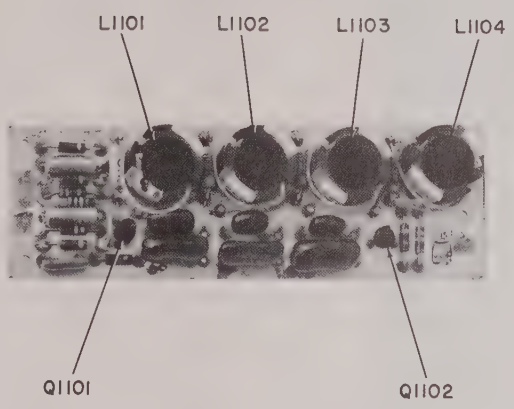


Figure 5-3. Bandpass Filter

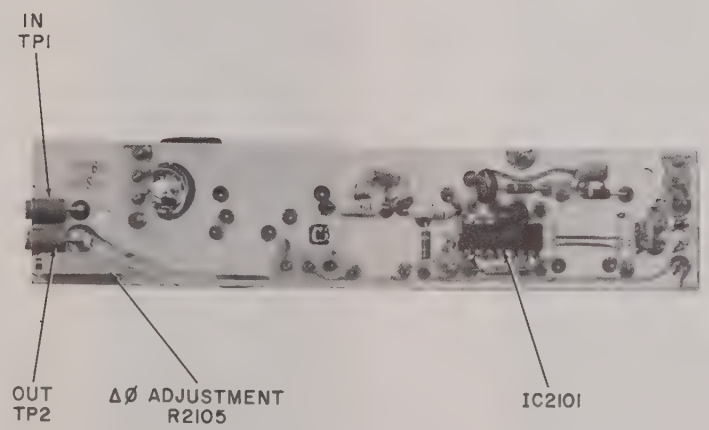


Figure 5-4. Low Pass Filter

Figure 5-2. Main Board, GFD-16A & B

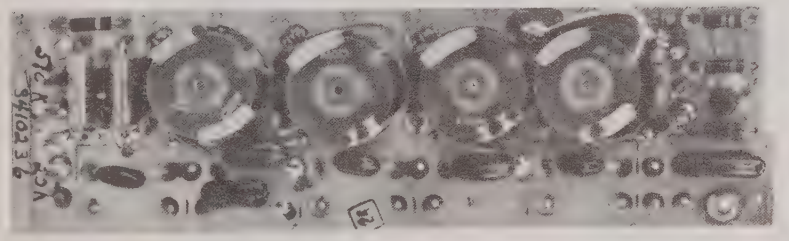
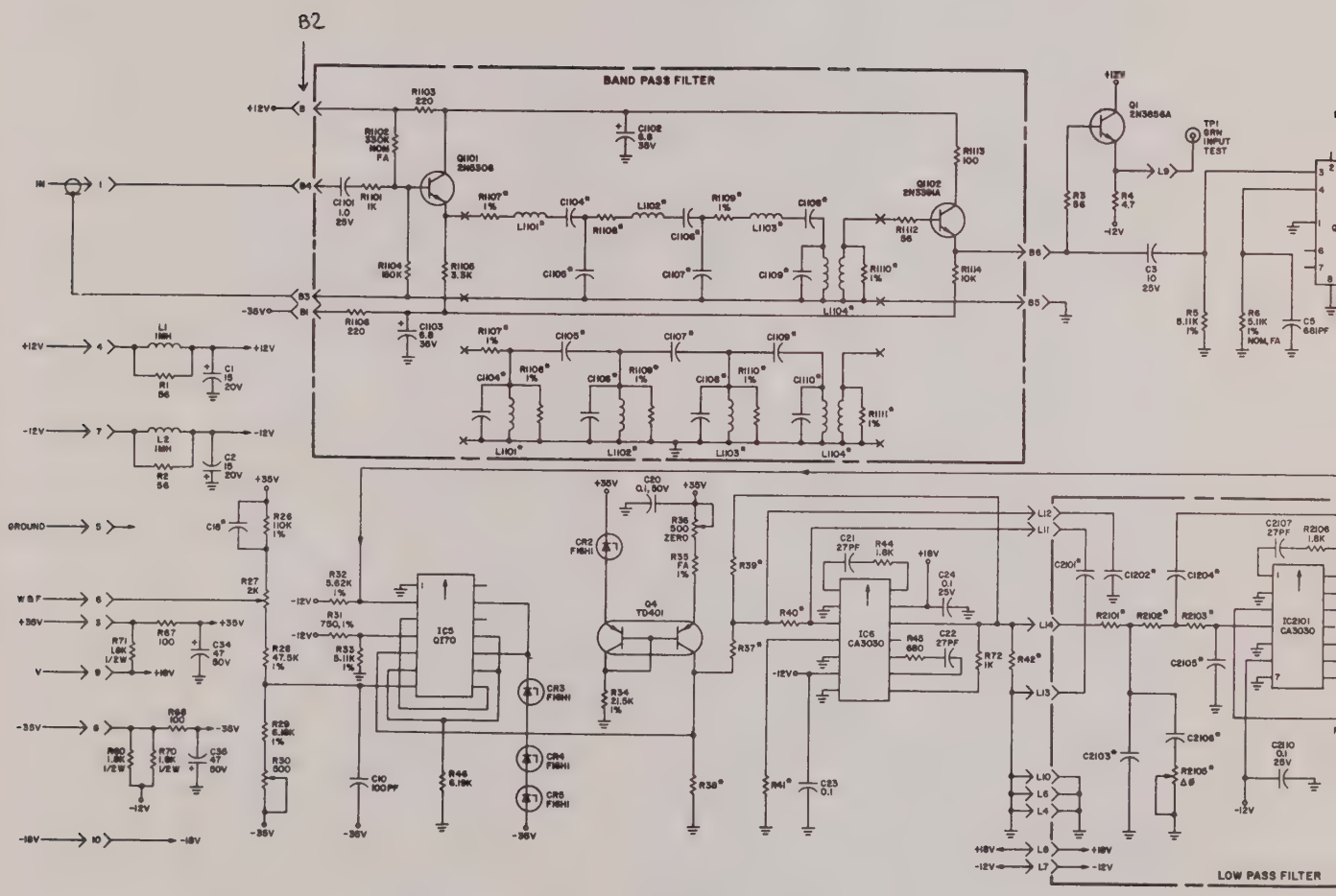


Figure 5-3. Bandpass Filter

Figure 5-4. Low Pass Filter

SECTION VI
SCHEMATIC DIAGRAMS


B2
BAND PASS FILTER
+12V
IN
-35V
GROUND
W.S.F.
+35V
-12V
+18V
-18V
Q1 2N3856A
TP1 GRN INPUT TEST
Q101 2N5306
Q102 2N5306A
IC5 QT70
IC6 CA3030
Q4 TD401
IC2101 CA3030
CR2 FHSHI
CR3 FHSHI
CR4 FHSHI
CR5 FHSHI
LOW PASS FILTER

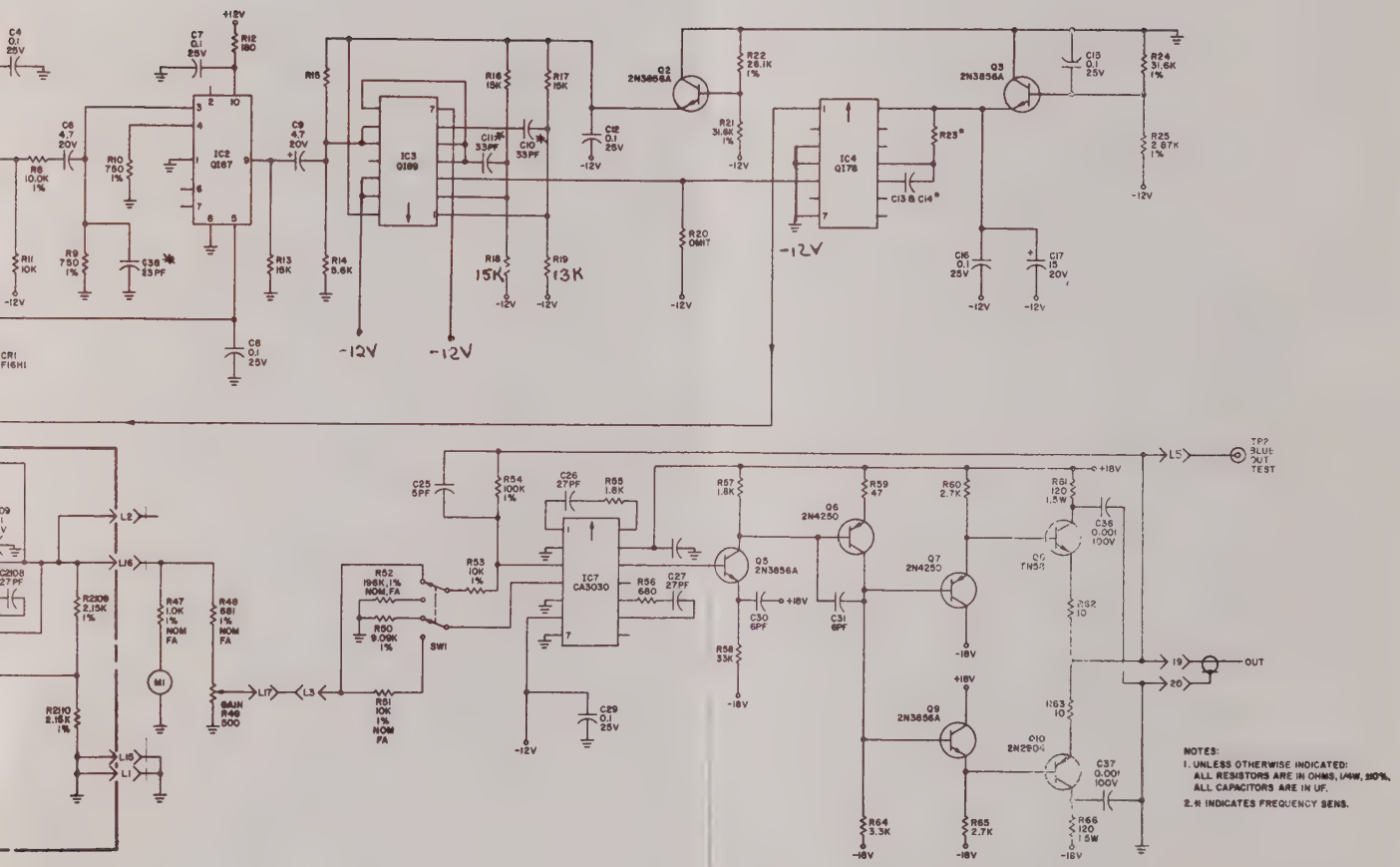
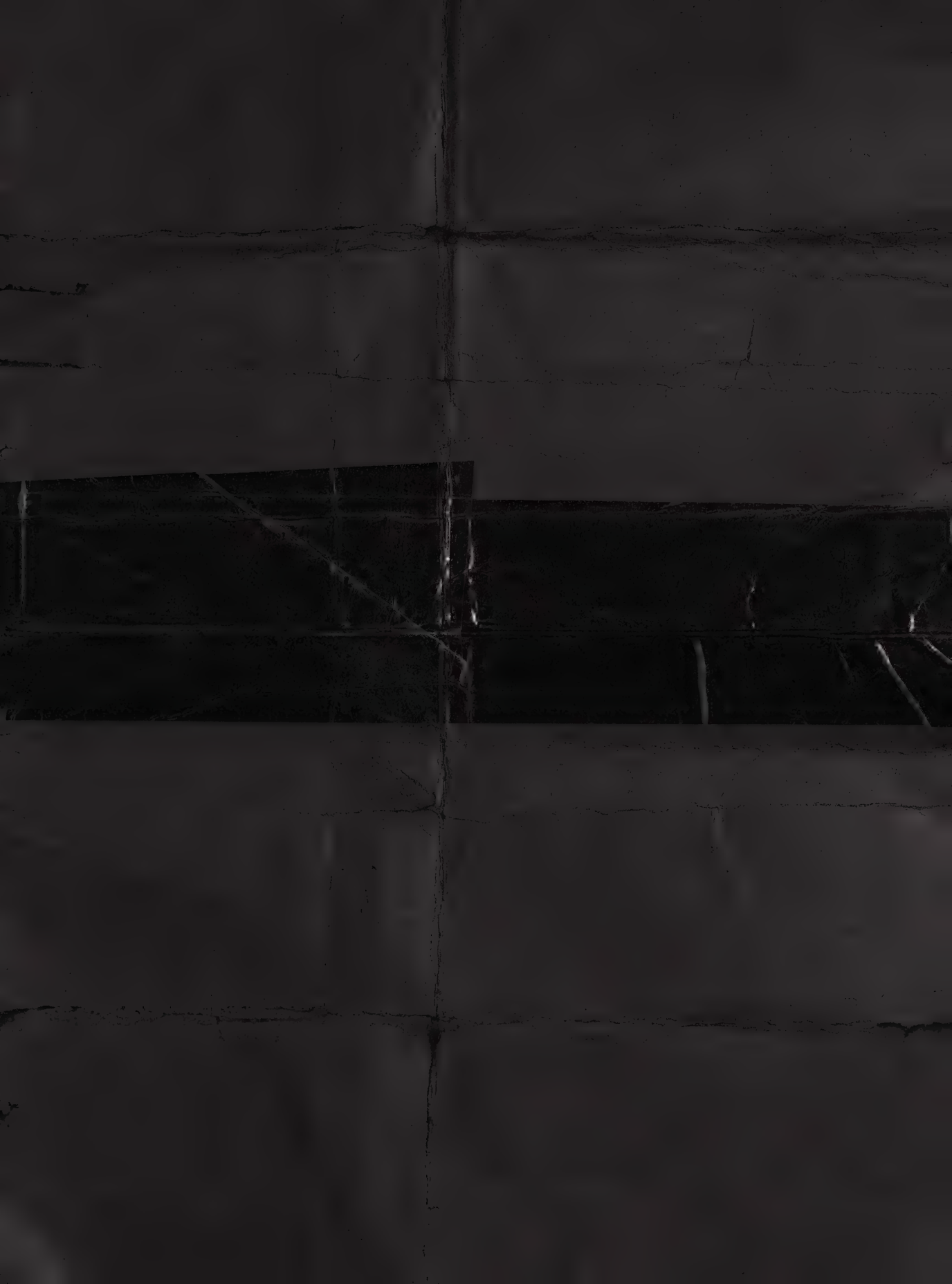
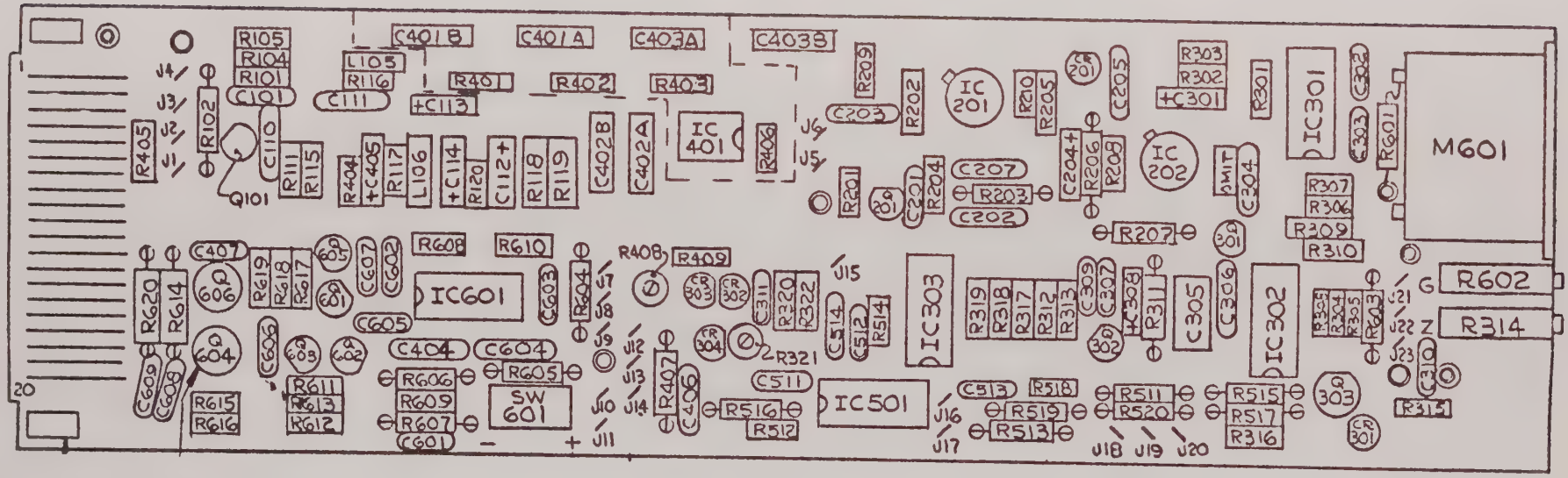
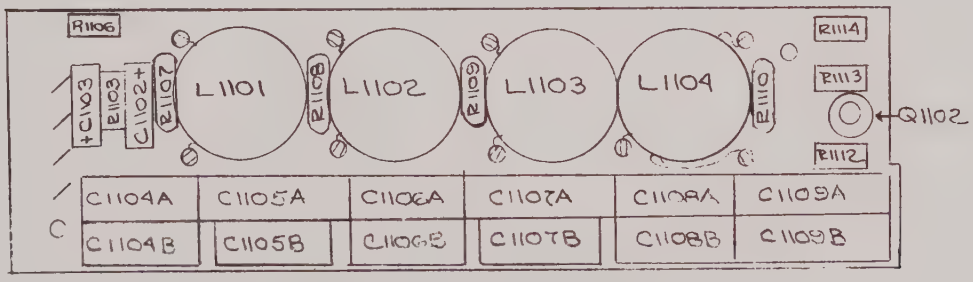


Figure 6-1. Schematic Diagram, Model GFD-16





MAIN BOARD - GFD-16A & GFD-16B
(components within dotted line omitted in GFD-16A)



BANDPASS FILTER BOARD

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	ADDED NOTE 3	3-13-72	D.R.W.

BANDPASS FILTER

BANDPASS FILTER
1100 SERIES (DCS MOD #341)

LIMITER

DEMODULATOR

LOW PASS FILTER

LOW PASS FILTER
2500 SERIES

OUTPUT AMPLIFIER

TAPE SPEED COMPENSATION

DEMODULATOR

SIGNAL

NOTES:
1. * FREQ SENS.
2. ALL RESISTERS ARE ¼W 10% UNLESS OTHERWISE SPEC.
3. INSTALL JUMPER (OMIT C401-C403, R401-R403, R406) (IC401 FOR 16A. FOR 16B ADD ABOVE MENTIONED PARTS & OMIT JUMPER
4. EXAMPLE OF FUNCTION & SERIES:
   - 100 SERIES - B/P (MAIN BD)
   - 1100 B/P (PLUG IN)
   - 200 LIMITER
   - 300 DEMODULATOR
   - 400 TAPE SPEED COMPENSATION
   - 500 L/P (MAIN BD)
   - 2500 L/P (PLUG IN)
   - 600 SERIES OUTPUT AMPLIFIER

REF	DESCRIPTION	QTY

020161	GFD-16A&B
NEXT ASSY	USED ON

APPLICATION

QTY REQD	PART OR IDENTIFYING NO	CODE IDENT	DESCRIPTION	SPECIFICATION OR VENDOR	SYMBOL	ITEM

LIST OF MATERIALS

DIMENSIONS AND TOLERANCES PER MIL STANDARD 8 UNLESS OTHERWISE SPECIFIED
TOLERANCES ON XXX ± XX ±
FRACTIONS ± ANGLES ±
FLATNESS WITHIN
HOLE TOLERANCE PER D C S SPECIFICATION AS-81401B, CLASS 1
BREAK ALL CORNERS AND EDGES, REMOVE BURRS .015 MAX
MATERIAL ±
FINISH ±

CONTRACT NO.
DRAWN D. R. WEST DATE 1-10-71
CHECKED
DESIGNER
PROJECT ENG
APPROVED
APPROVED
APPROVED

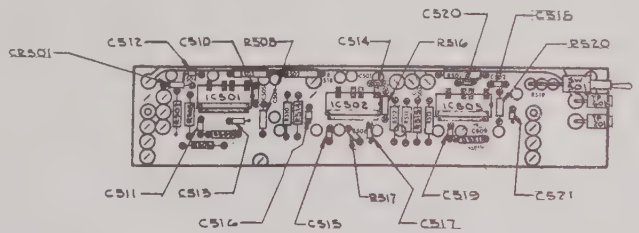
DATA-CONTROL SYSTEMS, INC.
DANBURY, CONN.

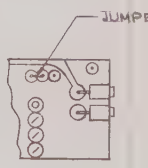
SCHEMATIC
DEMODULATOR
GFD-16A & B

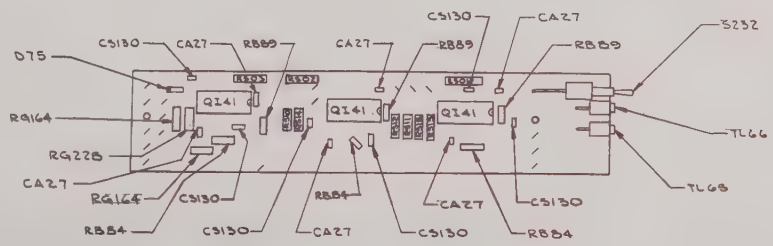
SIZE D | CODE IDENT 08539 | 020160

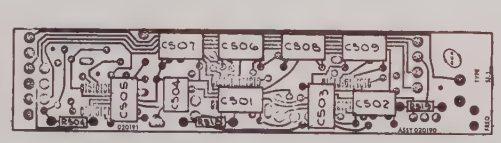
SCALE: ± | SHEET ±

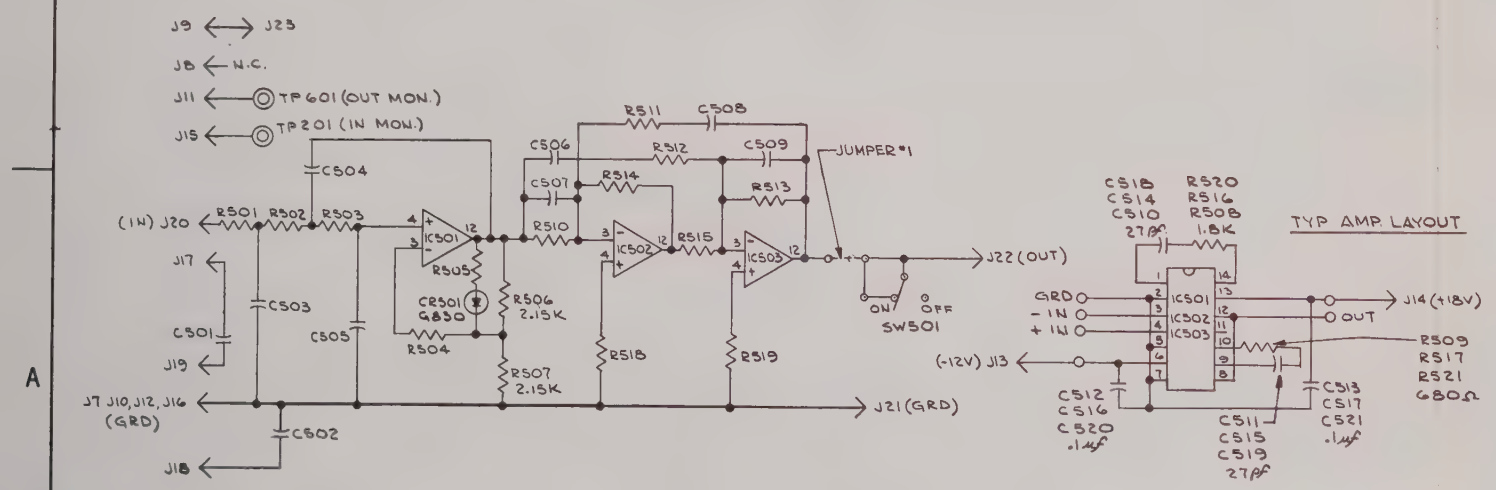
020160











REF	DESCRIPTION	QTY.

ALL COMPONENT DESIGNATIONS ARE 2500 SERIES, EXCEPT TP601 & TP201

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

QTY REQ'D -5	-2	-1	PART OR IDENTIFYING NO.	CODE IDENT.	DESCRIPTION	SPECIFICATION OR VENDOR	TOL'S.	SYMBOL	ITEM
					JUMPER #1				51
1	1	1	SKT-102-PC		BLUE JACK	SEALECTRO	TL66	TP2601	50
1	1	1	SKT-102-PC		GREEN JACK	SEALECTRO	TL68	TP2201	49
1	—	—	7101AV		SWITCH, SPDT	C&K	S232	SW2501	48
1	1	1	CA3030		INT. CIRCUIT	RCA	QI41	IC2503	47
1	1	1	CA3030		INT. CIRCUIT	RCA	QI41	IC2502	46
1	1	1	CA3030		INT. CIRCUIT	RCA	QI41	IC2501	45
1	—	—	G830		DIODE	ITT	D75	CR2501	44
1		1	CB		RESISTOR, 680Ω, 1/4W, 10%	A.B.	RB84	R2521	43
1		1	CB		1.8K, 1/4W, 10%	A.B	RB89	R2520	42
1		1			FREQ. SENSITIVE			R2519	41
1		1			FREQ. SENSITIVE			R2518	40
1		1	CB		680Ω, 1/4W, 10%	A.B	RB84	R2517	39
1		1	CB		1.8K, 1/4W, 10%	A.B.	RB89	R2516	38
1		1			FREQ. SENSITIVE			R2515	37
1		1			↕			R2514	36
1		1						R2513	35
1		1						R2512	34
1		1						R2511	33
1		1			FREQ. SENSITIVE			R2510	32
1		1	CB		680Ω, 1/4W, 10%	A.B	RB84	R2509	31
1		1	CB		1.8K, 1/4W, 10%	A.B.	RB89	R2508	30
1		1	MF5C-D		2.15K, 1/4W, 1%	ELECTRA	RG164	R2507	29
1		1	MF5C-D		2.15K, 1/4W, 1%	ELECTRA	RG164	R2506	28
1	—	—	MF5C-D		11K, 1/4W, 1%	ELECTRA	RG228	R2505	27
1		1			FREQ. SENSITIVE			R2504	26
1		1			↕			R2503	25
1		1						R2502	24
1		1			RESISTOR, FREQ. SENSITIVE			R2501	23
1		1	3C21		CAPACITOR, .1μf, 25V.	SPRAGUE	C5130	C2521	22
1		1	3C21		.1μf, 25V.	SPRAGUE	C5130	C2520	21
1		1	DM-10		27pf	DUR-MICA	CA27	C2519	20
1		1	DM-10		27pf.	DUR-MICA	CA27	C2518	19
1		1	3C21		.1μf, 25V.	SPRAGUE	C5130	C2517	18
1		1	3C21		.1μf, 25V.	SPRAGUE	C5130	C2516	17
1		1	DM-10		27pf	DUR-MICA	CA27	C2515	16
1		1	DM-10		27pf	DUR-MICA	CA27	C2514	15
1		1	3C21		.1μf, 25V	SPRAGUE	C5130	C2513	14
1		1	3C21		.1μf, 25V.	SPRAGUE	C5130	C2512	13
1		1	DM-10		27pf.	DUR-MICA	CA27	C2511	12
1		1	DM-10		27pf.	DUR-MICA	CA27	C2510	11
1		1			FREQ. SENSITIVE			C2509	10
1		1			↕			C2508	9
1		1						C2507	8
1		1						C2506	7
1		1						C2505	6
1		1						C2504	5
1		1						C2503	4
1		1						C2502	3
1		1			CAPACITOR, FREQ. SENSITIVE			C2501	2
1	1	1	C-020131		BOARD DETAIL L.P. FILTER				1

LIST OF MATERIALS

NEXT ASSY	USED ON
GFD-16/L	
APPLICATION	

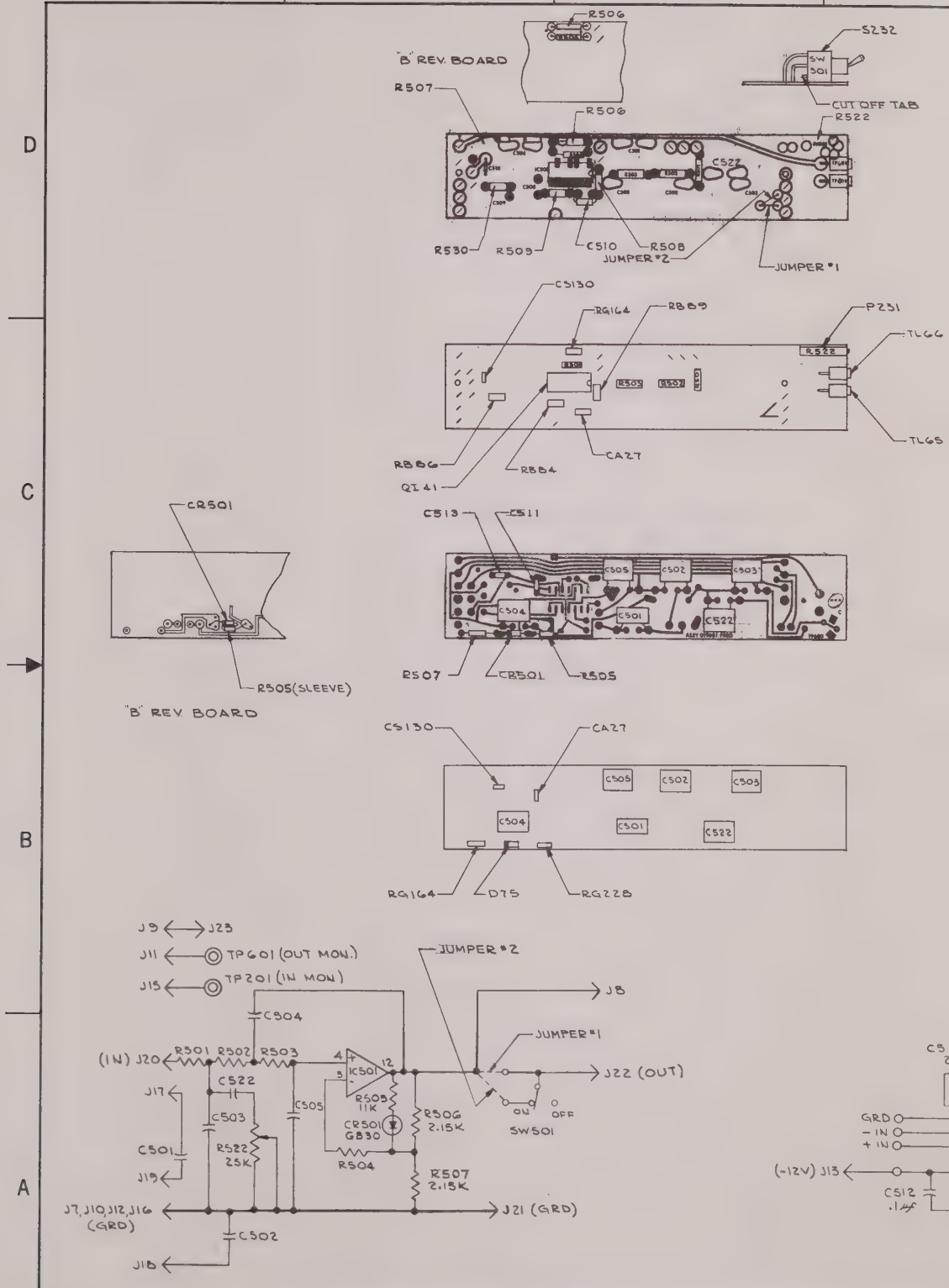
DIMENSIONS AND TOLERANCES PER MIL STANDARD 8
UNLESS OTHERWISE SPECIFIED
TOLERANCES ON:
XXX
FRACTIONS
ANGLES
XX
FLATNESS WITHIN
HOLE TOLERANCE PER D C S SPECIFICATION AS-814018, CLASS 3
BREAK ALL CORNERS AND EDGES, REMOVE BURRS .015 MAX
MATERIAL
FINISH

CONTRACT NO.
DRAWN J.C. Letzgus DATE 4/16/73
CHECKED
DESIGNER
PROJECT ENG
APPROVED
APPROVED
APPROVED

DATA-CONTROL SYSTEMS, INC.
DANBURY, CONN.

BOARD ASSEMBLY LOW PASS FILTER

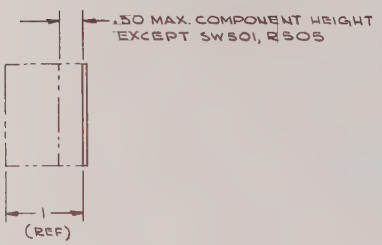
SIZE D | CODE IDENT. 08539 | M-020190
SCALE: FULL | SHEET 1 OF 1



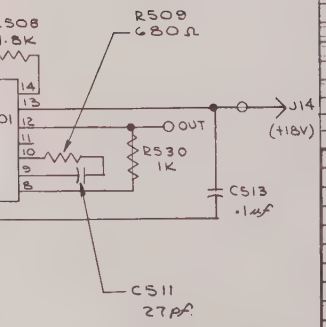
ALL COMPONENT DESIGNATIONS ARE 2500 SERIES, EXCEPT TP601 & TP201

REF.	DESCRIPTION	QTY.

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



QTY REQD			PART OR IDENTIFYING NO.	CODE IDENT.	DESCRIPTION	SPECIFICATION OR VENDOR		DCS	SYMBOL	ITEM
-3	-2	-1			LIST OF MATERIALS					
1	—	—			JUMPER #2					29
—	1	1			JUMPER #1					28
1	1	1	SKT-102-PC		BLUE JACK	SEALECTRO	TL66		TP601	27
1	1	1	SKT-102-PC		GREEN JACK	SEALECTRO	TL65		TP201	26
1	—	—	7101 AV		SWITCH, SPDT (MODIFIED)	C&K	S232		SW501	25
1	1	1	CA3030		INT. CIRCUIT	RCA	QI41		IC2501	24
1	—	—	GB30		DIODE	ITT	D75		CR2501	23
1	—	—	MF5C-D		RESISTOR, 11K, 1/4W, 1%	ELECTRA	RG228		R2505	22
1	1	1	MF5C-D		2.15K, 1/4W, 1%	ELECTRA	RG164		R2507	21
1	1	1	MF5C-D		2.15K, 1/4W, 1%	ELECTRA	RG164		R2506	20
1	1	1	CB		1K, 1/4W, 10%	AB	RB86		R2530	19
1	1	1	CB		680Ω, 1/4W, 10%	AB	RB64		R2509	18
1	1	1	CB		1.8K, 1/4W, 10%	AB	RB89		R2508	17
—	1	—	79 PR		25K	HELITRIM	P231		R2522	16
1	1	1			FREQ. SENSITIVE				R2504	15
1	1	1							R2503	14
1	1	1							R2502	13
1	1	1			RESISTOR, FREQ. SENSITIVE				R2501	12
1	1	1	3C21		CAPACITOR, .1μf 25V.	SPRAGUE	C5130		C2512	11
1	1	1	3C21		.1μf 25V.	SPRAGUE	C5130		C2513	10
1	1	1	DM-10		27pf.	DUR MICA	CA27		C2511	9
1	1	1	DM-10		27pf.	DUR-MICA	CA27		C2510	8
—	1	—			FREQ. SENSITIVE				C2522	7
1	1	1							C2505	6
1	1	1							C2504	5
1	1	1							C2503	4
1	1	1							C2502	3
1	1	1			CAPACITOR, FREQ. SENSITIVE				C2501	2
1	1	1	C-019680		BOARD DETAIL L.P. FILTER					1



DIMENSIONS AND TOLERANCES PER MIL STANDARD 8
UNLESS OTHERWISE SPECIFIED
TOLERANCES ON:
.XXX .XX
FRACTIONS ANGLES
FLATNESS WITHIN
HOLE TOLERANCE PER D C S SPECIFICATION AS-814018, CLASS 1
BREAK ALL CORNERS AND EDGES, REMOVE BURRS .015 MAX

CONTRACT NO.
DRAWN J.C. Lutzger DATE 4/16/73
CHECKED
DESIGNER
PROJECT ENG
APPROVED

MATERIAL
FINISH
APPROVED
APPROVED

NEXT ASSY GFD-16/L
USED ON
APPLICATION

DATA-CONTROL SYSTEMS, INC.
DANBURY, CONN.

BOARD ASSEMBLY LOW PASS FILTER

SIZE D | CODE IDENT. 08539 | M-019681

SCALE: FULL | SHEET 1 OF 1

SECTION VII
PARTS LIST

7-1. INTRODUCTION.

7-2. This parts list section includes all pertinent data necessary to locate, identify, and procure additional parts for the equipment. Parts are listed alpha-numerically by reference symbol and include all electronic items. In some cases, values, ratings and manufacturer sources shown are nominal and variations may be found. Satisfactory replacement may be made with either the listed component or an exact replacement of the part described in this list.

7-3. ORDERING INFORMATION.

7-4. The following instructions will aid in ordering parts from the parts list.

a. Address all inquiries or orders to:

Field Service Dept.
Data-Controls Systems, Inc.
Commerce Drive
Danbury, Conn. 06810

b. Include the following information:

(1) Model and Serial Number of instrument and assembly.
(2) Data-Control Systems Part Number.
(3) Reference Symbol Number.
(4) Description (as shown on list).
(5) Description of Assembly (such as center frequency, deviation, cutoff frequency, and filter type).

7-5. HOW TO USE THE PARTS LIST.

7-6. Paragraphs 7-7 through 7-11 describe the use and meaning of the five columns included in the parts list.

7-7. REF SYMBOL COLUMN. The Ref Symbol column contains an alpha-numerical listing of parts as they appear on equipment chassis, illustration, or schematic. The reference designation identifies the parts as to their component function in the instrument.

Note

Parts identified with an asterisk (*) following the reference symbol are recommended spare parts.

7-8. DESCRIPTION COLUMN. The Description column contains the identification of component parts including all pertinent specifications. When the description column is used for a part which is identical to a part which has already been described, reference is made to the identical part, and the remaining columns are left blank. In some instances, the part is selected to provide the required characteristics of the assembly, such as tuning unit center frequency and deviation, and low-pass filter cutoff frequency and filter characteristics. These parts are identified as "factory selected value." For these parts, it is not feasible to list the electrical characteristics of the part. Replacement of these parts should always be by an identical part, identification should be from the replaced part or by providing full information as specified in paragraph 7-4b(5).

7-9. MANUFACTURER'S PART NUMBER COLUMN. The Manufacturer's Part Number column contains the part number or type number as designated by the manufacturer of the part.

7-10. MANUFACTURER COLUMN. This column lists the true manufacturer of the part (vendor or DCS) except where the part is selected for particular characteristics by DCS. In this case, DCS is listed as the manufacturer and replacement must be made only by DCS part number.

7-11. TOTAL QTY COLUMN. The Total Qty column contains the number of identical parts in the equipment. This total does not include parts selected for specific characteristics (such as center frequency) since these quantities vary among different assemblies.

TABLE 7-1. PARTS LIST

Ref. Symbol	Description	Manufacturer	Mfr's Part No.	Total Qty
Unit Series	MAIN BOARD ASSEMBLY 019677			
C1-C2	Capacitor, Fixed, 15 UF, ±20%, 20V	Sprague	Type 150D	3
C3	Capacitor, Fixed, 1.0 UF, 25V	Sprague	Type 5C13	2
C4	Capacitor, Fixed, 0.1 UF, 25V	Sprague	Type 5C7	7
C5	Capacitor, Fixed, 1.0 UF, 25V	Sprague	Type 5C13	1
C6	Capacitor, Fixed, 4.7 UF, ±20%, 20V	Sprague	Type 150D	4
C7	Same as C4	Sprague	Type 5C7	
C8	Same as C4	Sprague	Type 5C7	
C9	Same as C6	Sprague	Type 150D	
C10-C11	Capacitor, Factory Selected Value			3
C12	Same as C4	Sprague	Type 5C7	
C13	Capacitor, Fixed, Factory Selected Value			1
C14	Capacitor, Fixed, Factory Selected Value			1
C15-C16	Capacitor, Fixed, 0.1 UF, 25V	Sprague	Type 3C21	13
C17	Same as C1	Sprague	Type 150D	
C18	Capacitor, Fixed, Factory Selected Value			1
C19	Capacitor, Fixed, 100 pF	Electro-Motive	Type DM-10	1
C20	Capacitor, Fixed, 0.1 UF, 50V	Sprague	Type 7C	1
C21-C22	Capacitor, Fixed, 27 pF	Electro-Motive	Type DM-10	6
C23	Same as C15	Sprague	Type 3C21	
C24	Same as C4	Sprague	Type 5C7	
C25	Capacitor, Fixed, 6 pF	Electro-Motive	Type DM-10	3
C26	Same as C21	Electro-Motive	Type DM-10	
C27	Same as C21	Electro-Motive	Type DM-10	
C28	Same as C15	Sprague	Type 3C21	
C29	Same as C4	Sprague	Type 5C7	
C30	Same as C25	Electro-Motive	Type DM-10	
C31	Same as C25	Electro-Motive	Type DM-10	
C32	Same as C4	Sprague	Type 5C7	
C33	Same as C15	Sprague	Type 3C21	
C34	Capacitor, Fixed, 4.7 UF, ±20%, 50V	Sprague	Type 150D	
C35	Same as C34	Sprague	Type 150D	
C36-C37	Capacitor, Fixed, .001 UF	RMC	Discap	2
C38	Capacitor, Fixed, Factory Selected Value	Electro-Motive		
CR1-CR5	Diode	General Electric	Type F16H1	5
L1-L2	Inductor, Fixed, 1 mH	Delevan	2500-28	2
IC1-IC2	Integrated Circuit	DCS/Motorola	QI67/MC1711C	2
IC3	Integrated Circuit	DCS/TI	QI89/74L00N	1
IC4	Integrated Circuit	DCS/TI	QI178/7412IN	1
IC5	Integrated Circuit	DCS/RCA	QI70/CA3046	1
IC6-IC7	Integrated Circuit	RCA	Type CA3030	6

TABLE 7-1. PARTS LIST (Cont'd)

Ref. Symbol	Description	Manufacturer	Mfr's Part No.	Total Qty
M1	Meter, 2-0-2 μA	EMICO	122D20	1
R1-R3	Resistor, Fixed, 56 ohms ±10%, 1/4 W	Allen Bradley	Type CB	4
R4	Resistor, Fixed, 4.7 K ohms ±10%, 1/4 W	Allen Bradley	Type CB	1
R5	Resistor, Fixed, 5.11 K ohms ±1%, 1/4 W	Electra	Type MF5C	2
R6	Resistor, Fixed, Factory Selected Value Nominally 5.11 K ohms ±10%, 1/4 W	Electra		1
R7	Resistor, Fixed, 180 ohms ±10%, 1/4 W	Allen Bradley	Type CB	2
R8	Resistor, Fixed, 4.64 K ohms ±1%, 1/4 W	Electra	Type MF5C	2
R9	Resistor, Fixed, 750 ohms ±1%, 1/4 W	Electra	Type MF5C	2
R10	Resistor, Fixed, Factory Selected Value, Nominally 750 ohms ±1%, 1/4 W			
R11	Resistor, Fixed, 10 K ohms ±10%, 1/4 W	Allen Bradley	Type CB	3
R12	Same as R7	Allen Bradley	Type CB	
R13	Resistor, Fixed, 15 K ohms ±10%, 1/4 W	Allen Bradley	Type CB	3
R14	Resistor, Fixed, 5.6 K ohms ±10%, 1/4 W	Allen Bradley	Type CB	1
R16	Same as R13	Allen Bradley	Type CB	
R17	Same as R13	Allen Bradley	Type CB	
R18-R19	Same as R16	Allen Bradley	Type CB	2
R21	Resistor, Fixed, 31.6 K ohms ±1%, 1/4 W	Electra	Type MF5C	1
R22	Resistor, Fixed, 26.1 K ohms ±1%, 1/4 W	Electra	Type MF5C	1
R23	Resistor, Fixed, Factory Selected Value			1
R24	Resistor, Fixed, 3.16 K ohms ±1%, 1/4 W	Electra	Type MF5C	1
R25	Resistor, Fixed, 2.87 K ohms ±1%, 1/4 W	Electra	Type MF5C	1
R26	Resistor, Fixed, 110 K ohms ±1%, 1/4 W	Electra	Type MF5C	1
R27	Resistor, Variable, 2 K ohms	Bechman	Type 62PR	1
R28	Resistor, Fixed, 47.5 K ohms ±1%, 1/4 W	Electra	Type MF5C	1
R29	Resistor, Fixed, Factory Selected Value Nominally 6.19 K ohms ±1%, 1/4 W	Electra	Type MF5C	2
R30	Resistor, Variable, 500 ohms	Beckman	Type 62PR	3
R31	Same as R9	Electra	Type MF5C	
R32	Resistor, Fixed, 5.62 K ohms ±1%, 1/4 W	Electra	Type MF5C	1
R33	Same as R5	Electra	Type MF5C	
R34	Resistor, Fixed, 21.5 K ohms ±1%, 1/4 W	Electra	Type MF5C	1
R35	Resistor, Fixed, Factory Selected Value Nominally 4640 ohms ±1%, 1/4 W			1
R36	Resistor, Variable, 500 ohms	Beckman	Type 79PR	
R37	Resistor, Fixed, Factory Selected Value			1
R38	Resistor, Fixed, Factory Selected Value			1
R39	Resistor, Fixed, Factory Selected Value			1
R40	Resistor, Fixed, Factory Selected Value			1
R41	Resistor, Fixed, Factory Selected Value			1
R42	Resistor, Fixed, Factory Selected Value			1

TABLE 7-1. PARTS LIST (Cont'd)

Ref. Symbol	Description	Manufacturer	Mfr's Part No.	Total Qty
R43	Resistor, Fixed, Factory Selected Value			1
R44	Resistor, Fixed, 1.8 K ohms ±10%, 1/4 W	Allen Bradley	Type CB	7
R45	Resistor, Fixed, 680 ohms ±10%, 1/4 W	Allen Bradley	Type CB	6
R46	Resistor, Fixed, 6.19 K ohms ±1%, 1/4 W	Electra	Type MF5C	
R47	Resistor, Fixed, Factory Selected Value, Nominally 1.00 K ohms ±1%, 1/4 W			1
R48	Resistor, Fixed, Factory Selected Value, Nominally 681 ohms ±1%, 1/4 W			1
R49	Same as R36	Beckman	Type 79PR	
R50	Resistor, Fixed, Factory Selected Value, Nominally 9.09 ohms ±1%, 1/4 W	Electra	Type MF5C	1
R51	Resistor, Fixed, Factory Selected Value, Nominally 10.0 K ohms ±1%, 1/4 W			1
R52	Resistor, Fixed, Factory Selected Value, Nominally 1.43 K ohms ±1%, 1/4 W			1
R53	Resistor, Fixed, 10.0 K ohms ±1%, 1/4 W	Electra	Type MF5C	
R54	Resistor, Fixed, 100 K ohms ±1%, 1/4 W	Electra	Type MF5C	1
R55	Same as R44	Allen Bradley	Type CB	
R56	Same as R45	Allen Bradley	Type CB	
R57	Same as R44	Allen Bradley	Type CB	
R58	Resistor, Fixed, 33 K ohms ±10%, 1/4 W	Allen Bradley	Type CB	1
R59	Resistor, Fixed, 47 ohms ±10%, 1/4 W	Allen Bradley	Type CB	1
R60	Resistor, Fixed, 2.7 K ohms ±10%, 1/4 W	Allen Bradley	Type CB	2
R61	Resistor, Fixed, 120 ohms, 1.5 W	Ohmite	#4094	2
R62	Resistor, Fixed, 10 ohms ±10%, 1/4 W	Allen Bradley	Type CB	
R63	Same as R62	Allen Bradley	Type CB	
R64	Resistor, Fixed, 3.3 K ohms ±10%, 1/4 W	Allen Bradley	Type CB	2
R65	Same as R60	Allen Bradley	Type CB	
R66	Same as R61	Ohmite	#4094	
R67-R68	Resistor, Fixed, 100 ohms ±10%, 1/4 W	Allen Bradley	Type CB	3
R69-R71	Resistor, Fixed, 1.8 K ohms ±10%, 1/2 W	Allen Bradley	Type EB	3
R72	Resistor, Fixed, 1 K ohm ±10%	Allen Bradley	Type CB	3
SW1	Switch, DPDT	Chicago Switch	#23-021-114	1
Q1-Q3	Transistor	General Electric	2N3856A	5
Q4	Transistor	Sprague	TD401	1
Q5	Same as Q1	General Electric	2N3856A	
Q6-Q7	Transistor	Fairchild	2N4250	
Q8	Transistor	Sprague	TN53	1
Q9	Same as Q1	General Electric	2N3856A	
Q10	Transistor	Motorola	2N2904	1

TABLE 7-1. PARTS LIST (Cont'd)

Ref. Symbol	Description	Manufacturer	Mfr's Part No.	Total Qty
1100 Series	BANDPASS FILTER WISE 019685			
C1101	Same as C3	Sprague	Type 5C13	
C1102-C1103	Capacitor, Fixed, 6.8 UF ±20%, 35 V	Sprague	Type 150D	
C1104	Capacitor, Fixed, Factory Selected Value			1
C1105	Capacitor, Fixed, Factory Selected Value			1
C1106	Capacitor, Fixed, Factory Selected Value			1
C1107	Capacitor, Fixed, Factory Selected Value			1
C1108	Capacitor, Fixed, Factory Selected Value			1
L1101	Inductor, Fixed, Factory Selected Value			1
L1102	Inductor, Fixed, Factory Selected Value			1
L1103	Inductor, Fixed, Factory Selected Value			1
L1104	Inductor, Fixed, Factory Selected Value			1
R1101	Same as R72	Allen Bradley	Type CB	
R1102	Resistor, Fixed, Factory Selected Value, Nominally 330 K ohms ±10%			1
R1103	Resistor, Fixed, 220 ohms ±10%, 1/4 W	Allen Bradley	Type CB	2
R1104	Resistor, Fixed, 150 K ohms ±10%, 1/4 W	Allen Bradley	Type CB	1
R1105	Same as R64	Allen Bradley	Type CB	
R1106	Same as R1103	Allen Bradley	Type CB	
R1107	Resistor, Fixed, Factory Selected Value			1
R1108	Resistor, Fixed, Factory Selected Value			1
R1109	Resistor, Fixed, Factory Selected Value			1
R1110	Resistor, Fixed, Factory Selected Value			1
R1112	Same as R1	Allen Bradley	Type CB	
R1113	Same as R67	Allen Bradley	Type CB	
R1114	Resistor, Fixed, 10 K ohms ±10%, 1/4 W	Allen Bradley	Type CB	1
Q1101	Transistor	General Electric	2N5306	1
Q1102	Transistor	General Electric	2N3391A	1
2100 Series	LOW PASS FILTER 019681			
C2101	Capacitor, Fixed, Factory Selected Value			1
C2102	Capacitor, Fixed, Factory Selected Value			1
C2103	Capacitor, Fixed, Factory Selected Value			1
C2104	Capacitor, Fixed, Factory Selected Value			1
C2105	Capacitor, Fixed, Factory Selected Value			1
C2106	Capacitor, Fixed, Factory Selected Value			1
C2107	Same as C21	Electro-Motive	Type DM-10	
C2108	Same as C21	Electro-Motive	Type DM-10	
C2109	Same as C15	Sprague	Type 3C21	
C2110	Same as C15	Sprague	Type 3C21	
IC2101	Same as IC6	RCA	Type CA3030	

TABLE 7-1. PARTS LIST (Cont'd)

Ref. Symbol	Description	Manufacturer	Mfr's Part No.	Total Qty
R2101	Resistor, Fixed, Factory Selected Value			1
R2102	Resistor, Fixed, Factory Selected Value			1
R2103	Resistor, Fixed, Factory Selected Value			1
R2104	Resistor, Fixed, Factory Selected Value			1
R2105	Resistor, Fixed, Factory Selected Value			1
R2106	Same as R44	Allen Bradley	Type CB	
R2107	Same as R45	Allen Bradley	Type CB	
R2108	Same as R72	Allen Bradley	Type CB	
R2109	Resistor, Fixed, 2150 ohms ±1%, 1/4 W	Electra	Type MF5C	4
R2110	Same as R2109	Electra	Type MF5C	
TP1-TP2	Test Point Note: TP1 - Green TP2 - Blue	Sealectro	SKT-102PC	
2300 Series	BOARD ASS'Y LOW PASS FILTER 019936			
C2301	Capacitor, Fixed, Factory Selected Value			1
C2302	Capacitor, Fixed, Factory Selected Value			1
C2303	Capacitor, Fixed, Factory Selected Value			1
C2304	Capacitor, Fixed, Factory Selected Value			1
C2305	Capacitor, Fixed, Factory Selected Value			1
C2306	Capacitor, Fixed, Factory Selected Value			1
C2307	Capacitor, Fixed, Factory Selected Value			1
C2308	Capacitor, Fixed, Factory Selected Value			1
C2309	Capacitor, Fixed, Factory Selected Value			1
C2310-11	Capacitor, Fixed, 27 pF	Electro-Motive	Type DM-10	6
C2312	Same as C15	Sprague	Type 3C21	
C2313	Same as C15	Sprague	Type 3C21	
C2314	Same as C2310	Electro-Motive	Type DM-10	
C2315	Same as C2310	Electro-Motive	Type DM-10	
C2316	Same as C15	Sprague	Type 3C21	
C2317	Same as C15	Sprague	Type 3C21	
C2318	Same as C2310	Electro-Motive	Type DM-10	
C2319	Same as C2310	Electro-Motive	Type DM-10	
C2320	Same as C15	Sprague	Type 3C21	
C2321	Same as C15	Sprague	Type 3C21	
CR2301	Diode	International Telephone & Telegraph Corporation	G830	1
IC2301	Same as IC6	RCA	Type CA3030	
IC2302	Same as IC6	RCA	Type CA3030	
IC2303	Same as IC6	RCA	Type CA3030	
R2301	Resistor, Fixed, Factory Selected Value			1
R2302	Resistor, Fixed, Factory Selected Value			1

TABLE 7-1. PARTS LIST (Cont'd)

Ref. Symbol	Description	Manufacturer	Mfr's Part No.	Total Qty
R2303	Resistor, Fixed, Factory Selected Value			1
R2304	Resistor, Fixed, Factory Selected Value			1
R2305	Resistor, Fixed, 11.0 K ohms ±1%	Electra	Type MF5C	1
R2306	Same as R2109	Electra	Type MF5C	
R2307	Same as R2109	Electra	Type MF5C	
R2308	Same as R44	Allen Bradley	Type CB	
R2309	Same as R45	Allen Bradley	Type CB	
R2310	Resistor, Fixed, Factory Selected Value			1
R2311	Resistor, Fixed, Factory Selected Value			1
R2312	Resistor, Fixed, Factory Selected Value			1
R2313	Resistor, Fixed, Factory Selected Value			1
R2314-R2315	Resistor, Fixed, 1.00 K ohm ±1%	Electra	Type MF5C	2
R2316	Same as R44	Allen Bradley	Type CB	
R2317	Same as R45	Allen Bradley	Type CB	
R2318	Resistor, Fixed, Factory Selected Value			1
R2319	Resistor, Fixed, Factory Selected Value			1
R2320	Same as R44	Allen Bradley	Type CB	
R2321	Same as R45	Allen Bradley	Type CB	
S2301	Switch, N.C-SPST	Gravhill	39-2	1
TP-1	Same as TP-1 Green	Sealectro	SKT-102PC	
TP-2	Same as TP-2 Blue	Sealectro	SKT-102PC	

TABLE 7-1. PARTS LIST (GFD-16A & GFD-16B)

Ref. Symbol	Description	Manufacturer	Mfg's. Part #	Total Qty.
Unit Series	MAIN BOARD ASSEMBLY 020161			
C101	Capacitor, Fixed, 1.0μf, 25V	Sprague	Type 5C7	3
C110-C111	Same as C101			
C112	Capacitor, Fixed, 4.7μf, 20%, 50V	Sprague	Type 150D	2
C113-114	Capacitor, Fixed, 15μf, 20%, 20V	Sprague	Type 150D	3
C201-202	Same as C101			
C203	Capacitor, Fixed, 0.1μf, 25V	Sprague	Type 5C7	7
C204	Capacitor, Fixed, 4.7μf, 20%, 20V	Sprague	Type 150D	2
C205	Same as C203			
C206	Capacitor, Factory Selected Value			
C207	Same as C203			
C301	Same as C204			
C302-303	Capacitor, Factory Selected Value			
C304	Same as C203			
C305-306	Capacitor, Factory Selected Value			
C307	Capacitor, Fixed, 0.1μf, 25V	Sprague	Type 3C21	5
C308	Same as C113			
C309	Same as C307			
C310	Capacitor, Fixed, 0.1μf, 50V	Sprague	Type 7C	1
C311	Capacitor, Fixed, 100 pf	Electro-Motive	Type DM-10	1
C401-403*	Capacitor, Factory Selected Value			
C404	Same as C203			
C405	Same as C307			
C511-512	Capacitor, Fixed, 27 pf	Electro-Motive	Type DM-10	3
C513	Same as C307			
C514	Same as C203			
C601	Capacitor, Fixed, 6pf	Electro-Motive	Type DM-10	2
C602-603	Same as C511			
C604	Same as C203			
C605-606	Same as C601			
C607	Same as C307			
C608-609	Capacitor, Fixed, .001μf	RMC	Discap	1
CR201	Diode	GE	Type F16H1	5
CR301-304	Same as CR201			
L105-106	Inductor, Fixed, 1mH	Delevan	2500-28	2
IC201-202	Integrated Circuit	DCS	Q167	2
IC301	Integrated Circuit	DCS	Q189	1
IC302	Integrated Circuit	DCS	Q178	1
IC303	Integrated Circuit	DCS	Q170	1
IC401*	Integrated Circuit	Texas Inst.	72741P	1
IC502	Integrated Circuit	RCA	CA3030	2
IC601	Same as IC502			

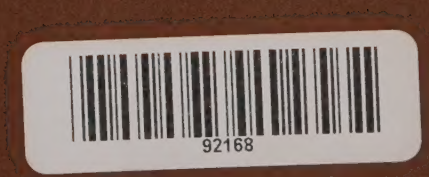
* Not in GFD-16A.

Ref. Symbol	Description	Manufacturer	Mfg's. Part #	Total Qty.
M601	Meter, 2-0-2 μA	EMICO	122D20	1
R101	Resistor, Fixed, 1K, 10%, ¼w	Allen Bradley		2
R102	Resistor, F.A., 300K nom., 10%, ¼w	Allen Bradley		1
R104	Resistor, Fixed, 150K, 10%, ¼w	Allen Bradley		1
R105	Resistor, Fixed, 3.3K, 10%, ¼w	Allen Bradley		2
R111	Resistor, Fixed, 200 ohm, 10%, ¼w	Allen Bradley		2
R115	Same as R111			
R116-117	Resistor, Fixed, 56 ohm, 10%, ¼w	Allen Bradley		3
R118-119	Resistor, Fixed, 1.8K, ½w	Allen Bradley	Type EB	3
R120	Resistor, Fixed, 100 ohm, ¼w	Allen Bradley		2
R201	Same as R116			
R202	Resistor, Fixed, 5.11K, 1%, ¼w	Electra		2
R203	Resistor, Factory Adjust, 5.11 nominal, 1%	Electra		1
R204	Resistor, Fixed, 180 ohm, 10%, ¼w	Allen Bradley		2
R205	Resistor, Fixed, 4.64K, 1%, ¼w	Electra		
R206	Resistor, Fixed, 750 ohm, 1%, ¼w	Electra		2
R207	Resistor, Factory Adjust, 750 ohm nom., 1%	Electra		1
R208	Same as R204			
R209	Resistor, Fixed, 4.7K, 10%, ¼w	Allen Bradley		1
R210	Resistor, Fixed, 10K, 10%, ¼w	Allen Bradley		2
R302	Resistor, Fixed, 15K, 10%, ¼w	Allen Bradley		5
R303	Resistor, Fixed, 5.6K, 10%, ¼w	Allen Bradley		1
R304-307	Same as R302			
R309	Resistor, Fixed, 31.6K, 1%, ¼w	Electra		1
R310	Resistor, Fixed, 26.1K, 1%, ¼w	Electra		1
R312	Resistor, Fixed, 3.16K, 1%, ¼w	Electra		1
R313	Resistor, Fixed, 2.87K, 1%, ¼w	Electra		1
R314	Resistor, Variable, 500 ohm	Beckman	Type 79PR	2
R315	Resistor, Fixed, Factory Selected Value Nominally 4.64K, 1%, ¼w	Electra		
R316	Resistor, Fixed, 21.5K, 1%, ¼w	Electra		1
R317	Same as R202			
R318	Same as R206			
R319	Resistor, Fixed, 5.62K, 1%, ¼w	Electra		1
R320	Resistor, Fixed, Factory Selected Value Nominally 6.19K, 1%, ¼w	Electra		
R321	Resistor, Variable, 500 ohm	Beckman	Type 62PR	1
R322	Resistor, Fixed, 6.19K, 1%, ¼w	Electra		1
R401-403*	Resistor, Fixed, Factory Selected Value			
R404	Same as R120			
R405	Same as R118			
R406	Resistor, Fixed, Factory Selected Value			

* Not in GFD-16A.

Ref. Symbol	Description	Manufacturer	Mfg's. Part #	Total Qty.
R407	Resistor, Fixed, 110K, 1%, $\frac{1}{4}$w	Electra		1
R408	Resistor, Variable, 2K	Beckman	Type 62PR	1
R409	Resistor, Fixed, 47.5K, 1%, $\frac{1}{4}$w	Electra		1
R511	Resistor, Fixed, Factory Selected Value	Electra		
R512	Resistor, Fixed, 1.8K, 10%, $\frac{1}{4}$w	Allen Bradley		3
R513	Resistor, Fixed, Factory Selected Value	Electra		1
R514	Resistor, Fixed, 680 ohm, 10%, $\frac{1}{4}$w	Allen Bradley		2
R515-517	Resistor, Fixed, Factory Selected Value	Electra		
R518	Same as R101			
R519-520	Resistor, Fixed, Factory Selected Value	Electra		
R601	Resistor, Fixed, Factory Selected Value Nominally 1K, 1%, $\frac{1}{4}$w	Electra		
R602	Same as R314			
R603	Resistor, Fixed, Factory Selected Value Nominally 681 ohm, 1%, $\frac{1}{4}$w	Electra		
R604	Resistor, Fixed, Factory Selected Value Nominally 9.09K, 1%, $\frac{1}{4}$w	Electra		
R605	Resistor, Fixed, Factory Selected Value Nominally 10K, 1%	Electra		
R606	Resistor, Fixed, Factory Selected Value	Electra		
R607	Resistor, Fixed, 100K, 1%, $\frac{1}{4}$w	Electra		1
R608	Same as R512			
R609	Same as R210			
R610	Same as R514			
R611	Same as R512			
R612	Resistor, Fixed, 47 ohm, 10%, $\frac{1}{4}$w	Allen Bradley		1
R613	Resistor, Fixed, 2.7K, 10%, $\frac{1}{4}$w	Allen Bradley		2
R614	Resistor, Fixed, 120 ohm, 1.5w	Ohmite	Type 4094	2
R615-616	Resistor, Fixed, 10 ohm, 10%, $\frac{1}{4}$w	Allen Bradley		1
R617	Resistor, Fixed, 33K, 10%, $\frac{1}{4}$w	Allen Bradley		1
R618	Same as R105			
R619	Same as R613			
R620	Same as R614			
Q101	Transistor		2N5306	1
Q201	Transistor	GE	3N3856A	4
Q301-302	Same as Q210			
Q303	Transistor	Sprague	TD401	1
Q601	Same as Q201			
Q602-603	Transistor	Fairchild	2N4250	1
Q604	Transistor	Sprague	TN53	1
Q605	Same as Q201			
Q606	Transistor	Motorola	2N2904	1
SW601	Switch, DPDT	Chicago Switch	23-021-114	1

Ref. Symbol	Description	Manufacturer	Mfg's. Part #	Total Qty.
1100 Series	BANDPASS FILTER 020104			
C1102-1103	Capacitor, Fixed, 6.8μf, 20%, 35V	Sprague		2
C1104-1109	Capacitor, Fixed, Factory Selected Value			
L1101-1104	Inductor, Fixed, Factory Selected Value			
R1103	Resistor, Fixed, 220 ohms, 10%, $\frac{1}{4}$w	Allen Bradley	Type CB	2
R1106	Same as R1103			
R1107-1110	Resistor, Factory Selected Value			
Q1102	Transistor		2N3391A	1


92168